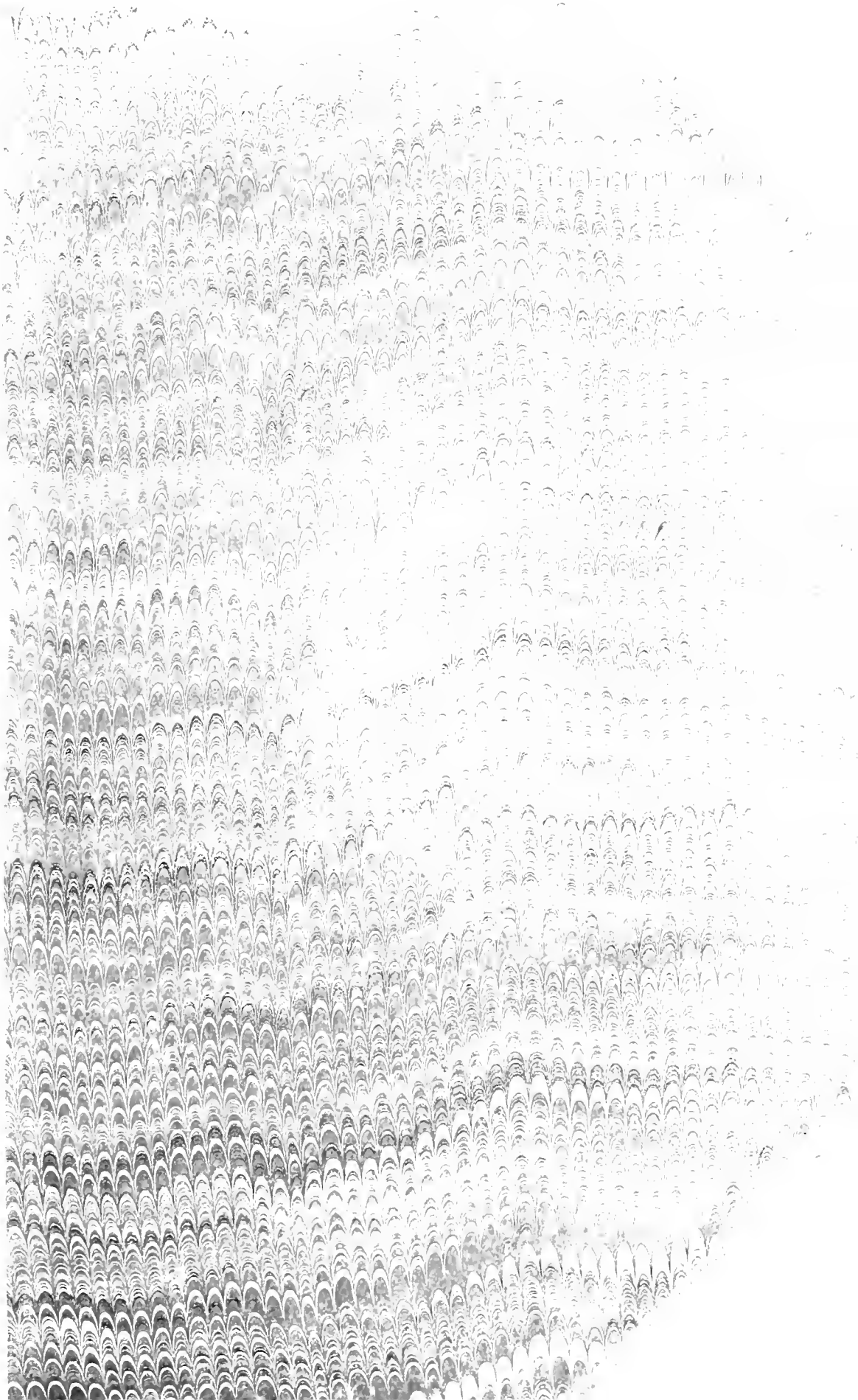

BULLETIN NO. 10.

OF THE

ILLINOIS STATE MUSEUM

OF

NATURAL HISTORY.

NEW SPECIES OF ECHINODERMATA AND A NEW CRUSTACEAN FROM THE PALÆOZOIC ROCKS.

By S. A. MILLER and Wm F. E. GURLEY.

Published quarterly by the Illinois State Museum of Natural History

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SOME NEW SPECIES OF ECHINODERMATA AND A NEW CRUSTACEAN FROM THE PALÆOZOIC ROCKS.

BY S. A. MILLER AND WM. F. E. GURLEY.

SUBKINGDOM ECHINODERMATA.

CLASS CRINOIDEA.

ORDER PALÆOCRINOIDEA.

FAMILY ACTINOCRINIDÆ.

ACTINOCRINUS SAMPSONI, n. sp.

Plate I, Fig. 1, opposite azygous side; Fig. 2, azygous side on the right.

Species medium size. Calyx obconoidal, rather wider than long, plates convex and radiately sculptured. Superior part of interradial areas slightly depressed.

Basals form a low cup about three times as wide at the top as high. It is truncated below, about one-third wider than the diameter of the column, and bears an hemispherical depression for the attachment of the column. First primary radials about as long as wide, three hexagonal, two heptagonal. Second primary radials a little wider than long, about two-thirds as large as the first and hexagonal. Third primary radials about as large as the second, four of them pentagonal, the one on the left of the azygous area hexagonal. They are axillary, and bear upon each upper sloping side a single secondary radial, which is axillary, and, in four of the rays, bear upon each of the distal sides two tertiary radials, and upon each proximal side a single tertiary radial, which is axillary, and supports upon each upper side a single quaternary radial, which arrangement gives to each of these rays six arms. In the left lateral ray one of the proximal sides bears

two tertiary radials and no quaternary plates, which gives to this ray five arms. There are, therefore, twenty-nine arms and twenty-nine ambulacral openings to the vault in this species.

The interradial areas all connect with the plates of the vault. In each regular interradial area the first plate is about the size of a second primary radial. It is followed by two smaller plates in the second range, and these by two smaller plates in the third range, and these by a single elongated plate in the fourth range, in each of three areas, that unites with two plates belonging to the vault. In the other area there are two elongated plates, in the fourth range, that unite with the plates of the vault. There is an elongated plate in each interscondary area that separates the quaternary plates and unites with the plates of the vault in some of the areas. There are ten plates in the azygous area. The first one is in line with the first primary radials, but somewhat smaller. It is followed by two plates in the second range, three in the third, two in the fourth, and two narrow elongated plates in the fifth range, that unite with the plates of the vault.

The vault is highly convex, depressed toward the interradial areas, and covered by numerous polygonal plates, about one fourth of which bear spines. The proboscis is central, but broken off in our specimen.

This is the first twenty-nine armed species described from the Burlington Group, and so different from all thirty-armed species that no comparison with any of them is nesessary.

Found by F. A. Sampson, in whose honor the specific name is proposed, in the Burlington Group at Sedalia, Missouri, and now in his collection. Also found by R. A. Blair, and in the collection of S. A. Miller.

ACTINOCRINUS PETTISENSIS, n. sp.

Plate I. fig. 3. azygous side; fig. 4. opposite view.

Species medium size. Calyx obconoidal, one-third wider than high, plates convex and rather deeply, radiately sculptured.

Basals form a low cup, about four times as wide at the top as high. It is truncated below about one-half wider than the diameter of the colum and bears an hemispherical depression for the attachment of the column. First primary radials wider than long, three hexagonal, two heptagonal. Second primary radials nearly as long

as wide, about two-thirds as large as the first and hexagonal. Third primary radials a little smaller than the second, wider than long, pentagonal, axillary, and bear upon each superior sloping side a single secondary radial, which is axillary and in one of the lateral rays supports, upon each upper sloping side, one or two tertiary radials, which gives to this ray four arms. In each of the other four rays, one of the proximal sides of the secondary radials bears a tertiary radial, which is axillary, and supports, on each upper sloping side, a quaternary plate, which arrangement gives to each of these four rays five arms. There are, therefore, in this species, twenty-four arms and twenty-four ambulacral openings to the vault.

The interradial areas connect with the vault. There are six plates in each regular interradial area. The first one is about the size of a second primary radial: it is followed by two smaller plates, in the second range, and these by two plates, less than one-third as large, in the third range, and above these, one quite small and narrow plate separates the tertiary radials. There is a small intersecondary plate in some of the areas, but it does not connect with the vault. There are ten plates in the azygous area. The first one is in line with the first primary radials, but somewhat smaller. It is followed by two plates, in the second range, three in the third, three in the fourth, and one in the fifth range that unites with the plates of the vault.

The vault is very highly convex and bears a central proboscis. It is covered with numerous polygonal plates, more than half of which bear long robust spines.

This is the first twenty-four armed *Actinocrinus* ever described, from any group of rocks, and while, in general outline, it bears some resemblance to *Actinocrinus fossatus*, a forty-armed species, yet the differences are so manifest that it would be idle to draw any comparison between the two.

It was found by the indefatigable collector, R. A. Blair, in the Burlington Group, at Sedalia, Missouri, and is now in the collection of S. A. Miller.

ACTINOCRINUS BISCHOFFI, n. sp.

Plate III, Fig. 1, azygous side; Fig. 2, opposite view; some of the plates around the arm openings are broken.

Species large. Calyx obconoidal, about as long as wide, abruptly spreading near the arm openings, which are directed upward, and are not visible in a basal view. Truncated only the diameter of the column. Plates plain or slightly convex. Sutures beveled; no radial ridges.

Basals form a cup about two and a half times as wide as high, and which is moderately constricted in the middle part. First primary radials as long as wide, three hexagonal, two heptagonal. Second primary radials about half as large as the first, hexagonal, and a little wider than long. Third primary radials smaller than the second, the one opposite azygous area heptagonal, three hexagonal and one pentagonal, axillary, and support on each upper side a secondary radial, which is axillary and supports, on each of the distal sides, four tertiary radials, and upon each of the proximal sides an axillary tertiary radial, which supports, on each upper side two or three quaternary radials, which arrangement gives to each of the rays six arms. There are, therefore, thirty ambulacral openings to the vault in this species.

None of the interradial areas connect with the vault. In each of three of the regular interradial areas there are seven plates, one, followed by two, in the second range, two in the third range, and two in the fourth range, which are below the tertiary radials. In the other area there are eight plates, the additional one being in the fifth range. There is a small intersecondary plate in the ray opposite the azygous area. There are thirteen plates in the azygous area. The first one is in line with the first primary radials and of the same size. It is followed by three plates, in the second range, four plates in the third range, three in the fourth range, one in the fifth range, and one in the sixth range. The last plate is small and below the union of the last two tertiary radials, in the adjoining radial series.

The vault is highly convex and covered with small, convex, polygonal plates. It bears a subcentral proboscis. The arm openings are directed upward and visible in a summit view. No ovarian pores have been discovered.

This is a very strongly marked and distinct species, and bears so little resemblance to any other one that has been described that no comparison with any of them is necessary. In form it is somewhat like *A. glans*, but that is a twenty-armed species, has fewer plates, in the interradial areas, and has only two plates in the second range, in the azygous area. Indeed, they have too little resemblance to each other to make any useful comparison.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of Prof. Martin Bischoff, of Buffalo, New York, in whose honor we have proposed the specific name.

ACTINOCRINUS SPECTABILIS, n. sp.

Plate III, Fig. 3, azygous side.

Species below medium size. Calyx obpyramidal, about as long as wide, moderately truncated, most rapidly spreading toward the free arms. Ambulacral openings directed upward, and not visible in a basal view. Radial ridges defined. Interradial areas somewhat flattened and cut off from any connection with the vault, except by a single plate in the azygous area. Surface granular.

Basals form a low cup about two and a half times as wide as high. First primary radials longer than wide, three hexagonal, two heptagonal. Second primary radials about two-thirds as large as the first, hexagonal, and a little wider than long. Third primary radials a little smaller than the second, heptagonal, axillary and support on each upper sloping side a single secondary radial which is axillary and supports, on each upper sloping side, a single tertiary radial, which gives to each ray four arms. There are, therefore, twenty arms in this species.

In each of the regular interradial areas there are five plates, one, followed by two, in the second range, and two in the third range. In each of the other regular interradial areas there are seven plates, one in the first range, two in the second, two in the third and two in the fourth, the last being cut off from any connection with the vault by the union of the tertiary radials. In the azygous area there are sixteen plates. The first one is in line with the first primary radials and of about the same size. It is followed by two plates in the second range, four in the

third range, five in the fourth range, three in the fifth range, and one in the sixth range that separates the tertiary radials and extends to the vault plates.

The vault is depressed, convex, covered with small polygonal plates, and bears a small subcentral proboscis. The ambulacral openings are directed upward and visible in a summit view. No ovarian pores discovered.

This species is distinguished by its general form from all other twenty-armed species heretofore described, and no comparison with any of them is necessary.

It was found in the Burlington Group, at Burlington, Iowa, and is now in the collection of S. A. Miller.

ACTINOCRINUS SOBRINUS, n. sp.

Plate III, Fig. 4, azygous side; Fig. 5, opposite view.

Species below medium size. Calyx obpyramidal one-half wider than high, truncated only the size of the column, most rapidly spreading toward the free arms. Ambulacral openings directed upward and not visible in a basal view. Radial ridges strongly defined. Interradial areas flattened in the lower part and depressed between the arms, where the plates unite with those of the vault. Plates convex.

Basals form a low cup three times as wide as high. First primary radials wider than long, three hexagonal and two heptagonal. Second primary radials about half as large as the first, hexagonal, wider than long. Third primary radials about as large as the second, three hexagonal, two heptagonal, axillary and support on each upper sloping side a single secondary radial, which is axillary and supports, on each upper sloping side, a single tertiary radial, which gives to each ray four arms. There are, therefore, twenty arms in this species.

There are seven plates in each regular interradial area, one in the first range, two in the second range, two in the third range, and two in the fourth range, which separate the tertiary radials and unite with the plates of the vault. There are fourteen plates in the azygous area. The first is in line with the lower part of the first primary radials, and rather more than half as large as one of them. It is followed by a single plate in the second range of about the same size. Suppose this to be abnormal, then

these two plates would represent the first plate, as usually found in this genus, and the two plates would be larger than a first primary radial and it would reduce the number of plates, in the azygous area, to thirteen. We are of the opinion that this feature is abnormal and that another specimen may show a single plate instead of two. In the next range there are three plates, in the next four, in the next three, and in the next two, which separate the tertiary radials and unite with the plates of the vault.

The vault is depressed, convex, covered with polygonal plates, and bears a small subcentral proboscis. The ambulacral openings are directed upward and visible in a summit view. No ovarian pores discovered:

This species is a cousin of *A. spectabilis*, above described, if not nearer related. It will be noticed that this is a shorter form, and radial ridges more prominent than in *A. spectabilis*, but such differences are not of specific importance when the arm formulas are the same. The differences between the two that may be of specific value are these: In this species each regular interradial area has seven plates, two of which connect with the plates of the vault: in *A. spectabilis* none of the plates in the regular interadial areas connect with the vault, and, in each of two of them, there are only five plates. In this species, supposing the division of the first plate, in the azygous area, to be normal, there are thirteen plates in the azygous area, the last two being comparatively large and connecting with the plates of the vault; in *A. spectabilis* there are sixteen plates, in the azygous area, only one of which connects with the plates of the vault. We have frequently found as much difference, in the number of interradials, in different specimens, in the same species, as we find in these two species; but not under the same circumstances. It is the difference in the number of plates, coupled with the fact that the interradial areas are connected with the vault in one case, and not in the other, that we are inclined to think is of specific value. There does not seem to be anything abnormal about our specimens except the division of the first azygous plate.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of A. Albers.

ACTINOCRINUS SUBSCITULUS, n. sp.

Plate III, Fig. 6, azygous side; Fig. 7, opposite view, Fig. 8, summit.

Species above medium size. Calyx obpyramidal, nearly as long as wide, truncated only the size of the column, most rapidly spreading near the free arms. Radial ridges well defined above the first primary radials. Interradial areas concave and depressed between the arms where the plates unite with those of the vault. Ambulacral openings directed upward and not visible in a basal view. Plates slightly convex. Surface granular.

Basals form a cup about twice as wide as high, and which is much constricted in the middle part. First primary radials longer than wide, three hexagonal, two heptagonal. Second primary radials less than half as large as the first, hexagonal, wider than long. Third primary radials about the size of the second, three heptagonal, two hexagonal, axillary, and support on each upper sloping side a single secondary radial, which is axillary, and in each of four of the rays support on each upper sloping side two tertiary radials, which gives to each of these rays four arms. In one of the lateral rays, the third primary radial supports, upon one side, an axillary, secondary radial, which supports upon each upper side two tertiary radials, and, upon the other side, a secondary radial that supports, on the distal side, two tertiary radials, and, upon the proximal side, an axillary tertiary radial, which bears upon each upper sloping side a quaternary radial, which arrangement gives to this ray five arms. There are, therefore, twenty-one arms in this species. The arm formula is 4+5+4+4+4.

The regular interradial areas connect with the vault, but they differ widely from each other. In one area there are eleven plates, in another ten, in another nine and in the other eight. Figure 7 shows one area with eight plates and the other with eleven plates. The azygous area is wide, flattened, and contains thirteen plates. The first plate is in line with the first primary radials, and of the same size. It is followed, in the second range, by two plates; in the third range, by five plates; in the fourth range, by four plates, and, in the fifth range, by one plate, that unites with the plates of the vault.

The vault is convex and covered with numerous, more or less convex, polygonal plates. It bears a subcentral proboscis. The arm openings are directed upward and are visible in a summit view. No ovarian pores discovered.

This is the first twenty-one armed *Actinocrinus* ever described from the Burlington Group, and hence there is no necessity for comparing it with any other species. Indeed, it is so far removed from all other species, in its essential structure, that it would be difficult to make a comparison with any of them.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of Wm. F. E. Gurley.

ACTINOCRINUS SUBPULCHELLUS, n. sp.

Plate III, fig. 12, azygous side; fig. 13, opposite view; fig. 14, summit.

Species medium or below medium size. Calyx obpyramidal, one-third wider than high, moderately truncated below, pentagonal above, in transverse section; radial ridges sharp, interradial areas flattened. Plates convex or nodose.

Basals form a low hexagonal cup, about three times as wide as high. The sutures are beveled, the basals are expanded below, and the sharp, radial ridges are extended across the basals, though not prominent. The first primary radials are as long as wide, three hexagonal, two heptagonal, and each one bears a central node. Second primary radials hexagonal, about two-thirds as large as the first, wider than long. Third primary radials smaller than the second, pentagonal, axillary, and support, on each upper sloping side, a single secondary radial which bears the free arms. There are, therefore, ten arms in this species. An intersecondary plate separates each pair of ambulacral openings to the vault.

The first regular interradials are rather larger than the second primary radials, slightly convex, not nodose. There are two plates in each second range and two in the third range that separate the arm openings and unite with the plates of the vault. The first azygous plate is in line with the first primary radials, of about the same size, and bears a central node. It is followed by two slightly convex plates, in the second range, three in the third range, and five smaller plates in the fourth range that separate the ambulacral openings and unite with the plates of the vault.

The vault is only moderately convex, covered with polygonal plates and bears a subcentral proboscis.

This species would seem to be more nearly related to *Actino crinus multiradiatus*, than to any other described species, but it is so different in form and in surface ornamentation that no comparison is necessary to distinguish them.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of Wm. F. E. Gurley.

PHYSETOCRINUS SAMPSONI, n. sp.

Plate I, fig. 5, azygous side; fig. 6, opposite view; fig. 7, summit.

Species medium size. Calyx obconical, rather broadly truncated below and stelliform, as seen from above, in consequence of the horizontal, rigid extension of the five radial series. The abrupt, horizontal extension of the radial series commences at the top of the third primary radials. Plates thick and nodose.

Basal plates form an hexagonal disc four times as wide as high, stand upright and evenly truncated below. The first primary radials are the largest plates in the body, about as long as wide, three hexagonal, two heptagonal. Second primary radials about one-third as large as the first and hexagonal. Third primary radials about half as large as the second, pentagonal, axillary, and support, on each superior side, a single secondary radial, which is axillary, and supports, on each upper side, a single tertiary radial, which gives to each ray four arms. There are, therefore, twenty arms in this species.

The interradial areas all connect with the vault, but they differ much from each other. The first plate is about the size of a second primary radial, and it is followed by two smaller plates, in the second range. In one of the areas there are four plates, in the third range, that separate the radial series and curve over upon the vault, where they unite with the summit plates. In each of the two areas, there are three plates, in the third range, that unite with the plates of the vault. In the other area there are two plates, in the third range, that are followed by three plates, in the fourth range, that curve over and unite with the plates of the vault. In the azygous area, the first plate is in line with the first primary radials and like them, except somewhat smaller. It is followed by two plates, in the second range, and

by three in the third range, one of which is elongated and curves over so as to unite with the plates of the vault. There are two plates, in the fourth range, even with the superior end of the elongated plate belonging to the third range, that unite with the plates of the vault.

The vault is depressed, convex, and covered with polygonal, slightly convex plates of very unequal size. The orifice is small and subcentral.

This species is so distinct from all others that no comparison with any of them is necessary. Heretofore, there has never been described a twenty-armed species of *Physetocrinus*, except *Physetocrinus copei*, which is far removed from this species, in all other respects.

Found by F. A. Sampson, in whose honor we have proposed the specific name, in the Burlington Group, at Sedalia, Missouri, and now in his collection.

DORYCRINUS ALABAMENSIS, n. sp.

Plate III, fig. 15, basal view; fig. 16, summit view; fig. 17, azygous side; the specimen illustrated is a cast from the chert.

Species medium size, calyx and vault subequal, outline subspheroidal, arms directed below a horizontal line. Calyx basin-shaped, rounded below, more than twice as wide as high. Ambulacral openings directed horizontally or below a horizontal line and not visible in a basal or summit view. This species is founded upon a very perfect cast in chert, of the interior of the test, and, therefore, does not show the surface ornamentation, or surface character of the plates except it shows the existence of radial ridges, by the radial furrows within the radial plates.

Basals form an hexagonal disc, very little larger than the diameter of the column, with a strongly marked re-entering angle on the azygous side. First primary radials, a little larger than wide, three hexagonal, two heptagonal. Second primary radials a little wider than long, three pentagonal, two hexagonal, caused by the slight truncation of some of the angles, by the plates, in the second interradial ranges. Third primary radials about the size of the second, three hexagonal, two pentagonal, axillary and supporting, upon each superior sloping side, two secondary radials,

the last being axillary and supporting, upon each outer sloping side, a free arm, which gives to each ray four arms. There are, therefore, twenty arms in this species.

In each regular interadial area there are five plates; one, followed by two in the second range, and two in the third range, which widely separate the arms and unite with the plates of the vault. In one area, however, the first plate is divided horizontally, so as to give the area six plates, which may or may not be abnormal. The azygous area is wide and the plates of the calyx graduate into those of the vault, without any distinct line of separation. The first plate is in line with the first primary radials and fully as large as either of them. It is followed by three plates, in the second range, the middle one being the smallest. There are four plates in the third range and four in the fourth range, the latter being of unequal size and forming an irregular range. Some of the plates, in the fifth range, abut upon the plates that surround the azygous orifice, which is situated upon the side, below the summit of the vault.

The vault is highly convex and has greater capacity than the calyx itself. There is a very large subcentral plate surrounded by eight plates, four of which are large, two are medium size, and the other two are smaller and abut upon the azygous orifice. The cast shows a pit in each of the four large plates, and in the interambulacral plates below, but there are none, in the ambulacral plates. There is also a pit subcentrally where the large subcentral plate rested. Probably these pits indicate spine-bearing plates.

This species bears little or no resemblance to any twenty-armed species heretofore described, and the test, if ever discovered, can probable be identified. At least, the test is as likely to be identified from the cast as the cast would have been from the test, if we had described the test instead of the cast. Twenty-armed species prevail, in the Keokuk Group, over other forms, and twelve and sixteen-armed species prevail in the Burlington Group, over other forms. The general form of this species is more like the prevailing forms in the Keokuk, than the prevailing forms in the Burlington, and without having examined the rocks from which it was collected, we suppose it was from the Keokuk Group.

Found at a place called Chert Hill, in Alabama, supposed to be of the age of the Keokuk Group, and now in the collection of Charles L. Faber.

DORYCRINUS SAMPSONI, n. sp.

Plate III, Fig. 20, azygous side; Fig. 21, opposite view; Fig. 22, summit, part of the spines are broken off.

Species above medium size. Body somewhat urn-shaped, base expanded, subcylindrical from the base of the third primary radials, and then abruptly expanded horizontally to the free arms, where the body has a subpentagonal outline, and above which the vault is perpendicularly elevated, preserving the subpentagonal outline a distance nearly equal to the height of the calyx and having a nearly flat summit. The expansion of the calyx from the basals to the third radials is less than the expansion of the base itself. The plates are convex or tumid. Ambulacral openings directed horizontally and not visible in a basal or summit view.

Basals the largest plate in the body, constricted in the superior part and broadly flanged below. The bottom is concave, and columnar canal small. First primary radials a little wider than long, each one bears a transverse central node, three hexagonal, two heptagonal. Second and third primary radials together very little more than half as large as the first. Second primary radials quadrangular, two or three times as wide as high. Third primary radials about the size of the second, three hexagonal, two pentagonial, curved outward, axillary, and, in the ray on each side of the azygous area bear a single secondary radial, on each outward sloping side, which is directed horizontally and bears upon each outward sloping side a single tertiary radial which gives to each of these rays four arms. In the ray opposite the azygous area, the third primary radial bears upon one outward side two secondary radials and upon the other an axillary secondary radial, which supports upon each outward side a single tertiary radial, which gives to this ray three arms. In each of the lateral rays, the third primary radial bears upon each superior, outward sloping side two secondary radials, which gives to each of these two arms. There are, therefore, fifteen arms in this species. The arm formula is $4 + 2 + 3 + 2 + 4$.

The regular interradial areas are elongated, unequal, and connected with the vault. In one area there are two plates, one, followed by an elongated plate that connects with the vault. In another area there are four plates, one, followed by two plates in the second range, and an elongated plate that connects with the vault, in the third range. In each of the other two areas there are three plates, one, followed by two in the second range, that connect with the plates of the vault. The interradial areas are depressed below the radials, which gives the subpentagonal outline to the body. The azygous area is nearly perpendicular from the constriction of the basals to the orifice, with a central longitudinal, convex ridge. The first azygous plate is in line with the first primary radials, larger than either one of them, and bears a transverse central node. It is followed, in the second range, by three plates, the middle one being the largest and most convex. The middle one is followed by two large nodose plates, the last one of which abuts upon the azygous orifice. The plates upon each side of the longitudinal central ridge, formed by these nodose plates above the second range, are small and depressed. On one side, below the plates surrounding the orifice, there are three plates and on the other four. The azygous orifice is surrounded by five plates and is situated below the level of the horizontally extended spines belonging to the vault.

The vault is elevated above the ambulacral openings so that a transverse section is subpentagonal, but it is stellate, as seen from above, by reason of a very large plate above each radial series terminating in a large spine, directed horizontally. In each of the lateral rays a large elongated plate separates the small ambulacral openings and extends to the inferior side of the spinous plate In the other rays an elongated plate occupies the same position, and laterally there are two plates extending to the spinous plate, the lower ones separating the ambulacral openings. The vault is nearly flat on the top, where it is covered by a few convex plates and a large central spinous plate. There are, therefore, six plates that terminate in spines, one central and directed upward and one over each radial series directed horizontally. Each spine is abruptly contracted or constricted, in the middle part, and then extends without tapering until it approaches the point. The point is broken off from each of the spines, in our specimen, but one of them is evidently nearly complete, as shown in the illustration.

There are two large, elongated plates in each interambulacral area, followed by two large plates, that separate the spine-bearing plates and curve over upon the vault. The central spine-bearing plate is surrounded by a circle of eleven plates, which nearly cover the summit.

There has never been but one fifteen-armed species described from the Burlington Group, and it has no resemblance to this one, and no comparison is therefore necessary to distinguish it. In general form it bears some resemblance to *D. intermedius* and *D. missouriensis*, but it is so widely different, without resorting to the arm formula, that they cannot be mistaken for each other. *D. intermedius* is a nineteen-armed species, and *D. missouriensis* a twelve-armed species.

Found by F. A. Sampson, in whose honor we have proposed the specific name, in the Burlington Group, at Sedalia, Missouri, and now in his collection.

DORYCRINUS FABERI, n. sp.

Plate I, Fig. 8, azygous side; Fig. 9, opposite view; Fig. 10, summit, part of the spines are broken off.

Species small. Calyx obpyramidal, from two to two and a half times as wide as high, truncated and flanged at the base. Radial ridges angular. Surface granular. Sutures not beveled. Column quite small.

Basals form a short subhexagonal disc, two and a half times as wide as the diameter of the column, the upper part being constricted and the lower part having a moderately concave depression, for the attachment of the column. First primary radials, the largest plates in the calyx, longitudinally angular in the middle, a little wider than long, three hexagonal, two heptagonal. Second primary radials about one-third as large as the first, quadrangular, and from two to two and a half times as wide as long. Third primary radials about one-half larger than the second, pentagonal, axillary, and, in four of the rays, support on each upper sloping side a single, secondary radial, which gives to each of these rays two arm openings to the vault. In the ray, on the right of the azygous area, the third primary radial bears upon the distal side two secondary radials and upon the proximal side a single second-

ary radial, which is axillary and supports, upon each upper sloping side, a single tertiary radial, which arrangement gives to this ray three arm openings to the vault. There are, therefore, eleven arm openings to the vault in this species.

In each regular interradial area there is one large, flat plate, followed by two narrow, elongated ones that unite with the plates of the vault. The first azygous plate is in line with the first primary radials and about as large as the smaller one. It is followed by three plates in the second range, the middle one being the largest. There are four plates in the third range, and one of the middle ones extends up to the azygous orifice and is truncated by it.

The vault is somewhat elevated over the ambulacral orifices and depressed convex centrally. The largest plate is subcentral, on the azygous side, and bears a long, robust spine. Each plate over a junction of the ambulacral canals bears a long spine. Otherwise the plates covering the vault are plane or slightly convex. Nine plates abut upon the subcentral, spine-bearing plate, two of which are truncated by the azygous orifice. Four plates only abut upon the minute azygous orifice, which is situated on a bulbous elevation, about on a level with the summit of the vault, and opens out horizontally.

This is the first eleven-armed *Dorycrinus* ever described, and hence it is distinguished, by that character alone, from all other species. The six spinous plates on the vault and plane surface of the other plates will distinguish it again from *D. unicornis*. It will also be distinguished from that species by the two plates in the second range, in each regular interradial area. And again, by the third range of plates, in the azygous area, and, again, by the fact that, in that species, there are numerous small plates surrounding the azygous orifice, while, in this, five plates constitute the azygous bulb and four of these abut upon the orifice. The surface of the plates, too, in the calyx of that species bears short spines or the plates are very tumid, while, in this, the plates are plane with the exception of the angular radial ridges. *Dorycrinus unicornis* has a wide range. We have examined it from various localities, in Iowa, from Adams county, Illinois, and from Sedalia, Blackwater and other places in Missouri, and the differences shown by the specimens from these distant localities are very slight, and usually consist in the character of the plates,

which differ in their convexity, some having cuneiform spines on the larger plates, and others having a plate here or there with a sharp spine. We have examined specimens varying from an eighth of an inch to an inch and a half in diameter, possessing, in every respect, the same substantial characters. Occasionally there is an increase in the number of plates, in the interradial or azygous areas or on the vault, from the normal number, but the radial plates and twelve ambulacral openings are features that remain unchanged.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of Charles L. Faber, in whose honor the specific name is proposed.

AMPHORACRINUS JESSIEÆ, n. sp.

Plate III. Fig. 18, azygous side, the vault retains part of the matrix, hence the transverse truncation of the figure; Fig. 19, basal view.

Species rather below medium size. Calyx bowl-shaped, somewhat broadly truncated or flattened below, and subpentagonal in transverse section above, nearly twice as wide as high. Radial ridges defined from the center of the first radial upward, and becoming stronger as the arms are approached. Plates convex and more or less pyramidal.

Basals form an hexagonal disc, with re-entering angles, about one-third wider than the diameter of the column, which attached in a moderately concave depression. First radials longer than wide, and abruptly curve upward from the central, angular, commencement of the radial ridges, three hexagonal, two heptagonal. Second radials about two-thirds as large as the first, wider than long, hexagonal. Third primary radials short, much smaller than the second, pentagonal, axillary, and support on each upper sloping side a single small secondary radial, which is axillary, and supports upon each superior sloping side a free arm. The secondary radials and arms are directed nearly horizontally. There are four arms to each ray, or twenty arms belonging to this species. The arms are very small and round on the lower side.

The interradial areas curve over upon the vault so as to leave the radial series standing out prominently. There are three regular interradials in each area. The first one is larger than a sec-

ond primary radial, and is followed by two plates in the second range that connect with the plates of the vault. The first azygous plate is in line with the first primary radials and somewhat smaller. It is followed by two plates in the second range, and by three in the third range, that connect with the plates of the vault.

The vault is depressed convex and bears a subcentral proboscis, but the matrix adheres, in our specimens, so as to prevent a full description of it.

This species is so different from all others that have been described that no comparison is necessary.

Found by Miss Jessie Blair, in whose honor we have proposed the specific name, in the Choteau limestone, at Sedalia, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS NODOSARIUS, n. sp.

Plate I, Fig. 11, side view, with azygous area on the right; Fig. 12, summit view.

Species medium or below medium size, biturbinate. Calyx obconoidal, in the lower part, and spreading, nearly horizontally, in the superior part, truncated at the base; about twice as wide as high; arm openings directed horizontally; plates convex, the larger ones tumid; surface granular.

Basals form a low cup or hexagonal disc, with slight re-entering angles, about twice as wide as the diameter of the column. It is constricted, in the upper part, and the plates extend a little below the point of columnar attachment. First radials tumid, about one-half wider than high, three hexagonal, two heptagonal. Second primary radials short, quadrangular, three or four times as wide as long. Third primary radials about twice as large as the second, pentagonal, axillary, and in each lateral ray, and, in the ray on each side of the azygous area, bear, upon each upper sloping side, two secondary radials. The second secondary radials are axillary, and, in each of the lateral rays, bear, upon each superior sloping side, two tertiary radials, which gives to each of these rays four arms. The proximal sides of the secondary radials, in each ray adjoining the azygous area, bear two tertiary radials, and the distal sides bear a single tertiary radial, which is axillary, and supports, upon one side, a single quaternary plate, and, upon the other, two quaternary plates, which arrangement gives to each

of these rays six arms. In the ray opposite the azygous area, the third primary radial bears, upon one side, four secondary radials, and upon the other, two, the last being axillary, and supporting, upon each upper sloping side, two tertiary radials, which gives to this ray three arms. There are, therefore, twenty-three arms in this species. The arm formula is 6+4+3+4+6.

In each regular interradial area there is a large tumid plate, and, in two of the areas, it is followed by a very small plate. The azygous area contains only four plates. The first one is in line with the first primary radials and quite as large as either of them. It is followed by three plates, the middle one being the largest, and cut off from the plates of the vault by the union of the quaternary radials above it.

The vault is highly convex and covered with numerous polygonal, nodose plates. It bears a subcentral proboscis.

This species differs, in general outline, and in the surface of the plates, from *B. subaequalis* of McChesney, which has three regular interradials in each area and seven or eight irregularly arranged plates, in the azygous area, beside the arm formula, in that species, is 6+4+4+4+5. The two species have so little resemblance to each other, though they have the same number of arms, that no further comparison is necessary. This species has even less resemblance to *B. pistillus* of Meek & Worthen, which has four regular interradials and seven or eight azygous plates and the arm formula of 5+4+4+5+5. These are the only twenty-three armed species, that have been described from the Burlington group, and our species cannot be mistaken for any other.

Found in the Burlington Group, of Adams county, Illinois, and now in the collection of Charles L. Faber.

BATOCRINUS LEVIS, n. sp.

Plate I, Fig. 13, basal view; Fig. 14, azygous side; Fig. 15, summit view.

Species medium or below medium size, calyx somewhat obconoidal, rounded below, broadly constricted in the middle and more or less quinquelobate when seen from above, caused by the depression, at the interradial areas. There is considerable variation of the forms in different specimens. Surface of the plates, plane and smooth, those of the vault sometimes slightly convex.

Basals form a low cup having a round, hemispherical depression below for the attachment of the column. In some specimens the lower part of the cup is rounded into the columnar depression, and upward from it, in others, there is more or less angularity. The cup at the top is about twice the diameter of the column. First radials the largest plates in the body, a little wider than long, three hexagonal, two heptagonal. Second radials small, quadrangular, three or four times as wide as long. Third radials very little larger than the second, pentagonal, axillary and bear upon each superior sloping side, in four of the rays, two secondary radials, the last ones being axillary and supporting on each upper side two tertiary radials, which gives to each of these rays four arms and four ambulacral openings to the vault. In the ray opposite to the azygous area, the third primary radial bears upon each superior sloping side three secondary radials which gives to this ray two arms. There are, therefore, eighteen arms and eighteen ambulacral openings to the vault in this species. The arm formula is 4 + 4 + 2 + 4 + 4, and there is no variation among the specimens examined.

There are three regular interradials in each area, one followed by two more or less elongated plates in the second range, which are cut off from the plates of the vault by the union of the last radials. The first one is in line with the first primary radials and nearly as large. It is followed by three subequal plates, in the second range, and by three plates, very unequal in size, in the third range. Above these, in the fourth range, there are two elongated plates that connect with the plates of the vault.

The vault is only moderately convex, except near the azygous orifice, where it is elevated more abruptly. It is depressed toward the margin, in the interradial areas. It is covered with smooth plates, some of which are convex. There is no proboscis, though the azygous orifice is somewhat elevated subcentrally. The ambulacral openings are directed upward, at an angle of about forty five degrees, and are seen in a summit view, but are not visible in a basal view of the calyx. No ovarian pores discovered.

This species bears little or no resemblance in general form or surface features to any other eighteen-armed described species and cannot be mistaken for any of them. In form and absence of surface ornamentation and position of the azygous orifice, it re-

sembles *Batocrinus hageri*, McChesney. That species, however, has twenty arms, four in each radial series, while this has only eighteen, or two only, in the ray opposite to the azygous area, and this feature alone is sufficient to distinguish the species. There are minor differences in the regular and azygous areas.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of A Albers, S. A. Miller and Wm. F. E. Gurley. The specimen illustrated is from the collection of Mr. Albers.

BATOCRINUS ENODIS, n. sp.

Plate I, Fig 16, basal view; Fig. 17, azygous side; Fig. 18, summit view.

Species variable in size and in form, one of the specimens examined has a diameter little more than half that of the one illustrated. Calyx and vault subequal in size, and much alike in form. Calyx saucer-shaped, rapidly expanding from the column to the arms. Ambulacral openings directed upward at an angle of about forty-five degrees, and not visible from a basal view. Surface of the plates plane and smooth, some of those on the vault sometimes slightly convex.

Basals form a low, concave, hexagonal disc, with obscure reéntering angles, having a round, hemispherical depression for the attachment of the column, and about one and a half times the diameter of the column. First primary radials nearly twice as wide as long, three hexagonal, two heptagonal. Second primary radials about half as large as the first, quadrangular, and two or two and a half times as wide as long. Third primary radials somewhat smaller than the first, twice as wide as long, three hexagonal, two pentagonal, axillary, and in one of the lateral rays, on each side, and in the ray opposite the azygous area, support on each superior lateral side, two secondary radials, the last ones being axillary and supporting on each upper side two tertiary radials, which gives to each of these three rays four arms and four ambulacral openings to the vault. In the ray on the right of the azygous area, the third primary radial bears upon the distal side two secondary radials, the last one being axillary and supporting, on the distal side, two tertiary radials, and, on the proximal side, one tertiary radial, which is axillary and supports upon each upper side a quaternary radial; and bears upon the proximal side

one secondary radial, which is axillary and supports, on the distal side, three tertiary radials, and, upon the proximal side, two tertiary radials, the last being axillary and supporting, on each upper sloping side, two quaternary radials, which arrangement gives to this ray six arms. In the ray on the left of the azygous area, the third primary radial bears, upon the distal side, two secondary radials, the last being axillary and supporting, upon each upper sloping side, two tertiary radials, and bears upon the proximal side one secondary radial, which is axillary and supports upon the distal side two tertiary radials, and upon the proximal side a single tertiary radial, which is axillary and supports on each superior side two quaternary radials, which arrangement gives to this ray five arms. There are, therefore, twenty-three arms and twenty-three ambulacral openings to the vault in this species. The arm formula is 6+4+4+4+5.

All of the interradial areas are cut off from the vault. In one of the regular interradial areas there are two plates, one following the other. In another area there are four plates, one followed by two, in the second range, and one in third. In each of the other two areas there are three plates, one followed by two, in the second range. This is the structure of the type specimen, but other specimens may show some differences in the regular areas. In the azygous area there are seven plates. The first plate is in line with the first primary radials, but not near as wide, though somewhat longer. It is followed by three rather large subequal plates, in the second range, and these by three, in the third range, the middle one of which is quite large and the lateral ones small. This area is entirely cut off from the vault by the union of the quaternary radials.

The vault is highly convex, or subconoidal, and covered with smooth, polygonal plates. The azygous orifice is subcentral and elevated above the surrounding summit, but there is no proboscis. The ambulacral openings are visible in a summit view. No ovarian pores discovered.

This species bears little or no resemblance to any other twenty-three armed species that has been described, either in general form or surface features, and cannot be mistaken for any of them. In its smooth surface it resembles *B. dodecadactylus*, *B. rotundus*, *B. oblatus*, *B. hageri*, *B. levis*, and other species herein described, though otherwise its affinities would seem to be with

B. rotundus and *B. obladus*. In form it approaches *B. rotundus*, but that species has twenty-one ambulacral openings to the vault, as follows: 5+4+4+4+4, while this species has twenty-three, as follows: 6+4+4+4+5. They also differ in the regular and azygous areas. It differs in form from *B. obladus*, which has twenty two arms, as follows: 5+4+4+4+5, and it differs in the azygous and interradial areas. There is no reason why it should be mistaken for either of these species. *B. rotundus* is the prevailing form in Missouri, where this species is yet unknown; while *B. obladus* is the prevailing form in Iowa and some localities in Illinois, where *B rotundus* also occurs, and where this species is also found.

Found in the Burlington Group, at Burlington, Iowa. The type is from the collection of S. A. Miller; other specimens are in the collection of A. Albers.

BATOCRINUS COMPLANUTUS, n. sp.

Plate I, Fig. 19, azygous side; Fig. 20, opposite view.

Species variable from below to above medium size. We have specimens smaller and others larger than the one illustrated. Vault smaller than the calyx. Calyx obconoidal, rapidly expanding from the column to the arms. Ambulacral openings directed above an horizontal line and not visible, in a basal view. Surface of the plates plain and smooth, some of them on the vault, sometimes slightly convex.

Basals form a low, hexagonal cup, with re-entering angles and having a round, hemispherical depression for the attachment of the column. The cup is a little more than twice the diameter of the column. First primary radials one-half wider than long, three hexagonal, two heptagonal. Second primary radials about one-third as large as the first, quadrangular, and about twice as wide as long. Third primary radials a little larger than the second, four hexagonal, one pentagonal, axillary, and in four of the rays bear, upon each superior sloping side, two secondary radials, the last of which are axillary and bear upon each upper sloping side two tertiary radials, which arrangement gives to each of these rays four arms and four ambulacral openings to the vault. In the ray opposite the azygous area the third primary radial

supports on one upper sloping side three secondary radials and upon the other two secondary radials, the last one being axillary and supporting upon each upper side two tertiary radials, which arrangement gives to this ray three arms. There are, therefore, nineteen arms and nineteen ambulacral openings to the vault in this species. The arm formula is 4+4+3+4+4.

All of the interradial areas are cut off from the vault. In each of the regular interradial areas there are three plates, one, followed by two in the second range. In each of the other two regular interradial areas there are four plates, one, followed by two in the second range and by one in the third range. In the azygous area there are eleven plates. The first plate is in line with the first primary radials and nearly as large. It is followed by three plates in the second range, four in the third range, two in the fourth range and one in the fifth range, which is cut off from the vault by the union of the second tertiary radials.

Vault highly convex or obconoidal, covered with smooth polygonal plates, and bearing a subcentral proboscis. The ambulacral openings are visible in a summit view. No ovarian pores discovered.

This species bears little or no resemblance in general form or surface features to either *B. attenuatus* or *B. nodulosus*, the other two nineteen-armed species heretofore described from the Burlington Group, and cannot be mistaken for either of them. In its smooth surface and general form its affinities would seem to be with *B. rotundus*, *B. oblatus* and *B. cnodis*, above described. This species, however, has only nineteen ambulacral openings to the vault, while *B. rotundus* has twenty-one, *B. oblatus* twenty-two and *B. cnodis* twenty-three. This, alone, is sufficient to distinguish the species. They differ further in the azygous and regular interradial areas, and this species bears a large subcentral proboscis, while *B. oblatus* and *B. cnodis* do not bear any, and *B. rotundus* bears a very small one.

Found in the Burlington Group, at Burlington, Iowa. The specimen illustrated is in the collection of A. Albers, and other specimens are in the collection of S. A. Miller.

BATOCRINUS LEVIGATUS, n. sp.

Plate I, Fig. 21, azygous side; Fig. 22, opposite view.

Species variable in size, from below medium to large. We have specimens less than half the size of the one illustrated. Vault smaller than the calyx. Calyx obconoidal and the larger specimens depressed, in the interradial areas, so as to give it a somewhat obpyramidal outline. It expands quite regularly from the column to the arms. Ambulacral orifices directed above an horizontal line and not visible in a basal view. Surface of the plates plane and smooth, some of those on the vault, sometimes, slightly convex.

Basals form an hexagonal disc about one-half wider than the diameter of the column, and bearing an hemispherical depression for its attachment. First primary radials wider than long, three hexagonal, two heptagonal. Second primary radials quadrangular, two or three times as wide as long. Third primary radials a little larger than the second, pentagonal, axillary, and, in the ray opposite the azygous area, bear upon each upper sloping side four secondary radials, which gives to this ray two arms. In the ray on the right of the azygous area, the third primary radial supports upon each upper sloping side two secondary radials, the last being axillary, and supporting on the distal sides three tertiary radials, and on the proximal sides two tertiary radials, which arrangement gives to this ray four arms. In the ray on the left of the azygous area (we speak of the right and left sides of a specimen as seen in the illustrations, without reference to the anterior and posterior sides), the distal side bears three secondary radials, the last being axillary, and supporting on each upper side two tertiary radials; and the proximal side bears two secondary radials, the last being axillary, and supporting on each upper sloping side three tertiary radials, which arrangement gives to this ray four arms. In the right lateral ray, the third primary radial bears upon each superior sloping side three secondary radials, the last ones being axillary, and one of them supporting upon each upper side two tertiary radials, and the other one supporting upon each upper side three tertiary radials, which arrangement gives to this ray four arms. In the left lateral ray, the third primary radial bears upon one upper sloping side three secondary radials, and, upon the other, two secondary radials, the last ones being axillary, and supporting on each upper side two tertiary radials, which gives to this ray

four arms. There are, therefore, eighteen arms and eighteen ambulacral openings to the vault in this species. The arm formula is 4+4+2+4+4. The irregularity of the radial series is very remarkable, and yet the calyx is as symmetrical as it is in many other species, and the same features occur in several specimens.

The interradial areas are different, but they are all cut off from the vault. In the area, on each side of the azygous area, there are three plates, one followed by two, in the second range. In each of the other areas there are four plates, one in the first range, two in the second range, and an elongated plate in the third range. In the azygous area there are eight plates. The first plate is in line with the first primary radials and nearly as large. It is followed by three plates in the second range, three in the third range and one in the fourth range, which is cut off, at a distance from the vault, by the union of the tertiary radials.

Vault highly convex or obconoidal, with slightly concave depressions toward the interradial areas. It is covered with smooth, polygonal plates, some of which are convex, and bears a subcentral proboscis. The ambulacral openings are visible in a summit view. No ovarian pores discovered.

This species is essentially different, in its structure and general form, from all other eighteen-armed species, and agrees with *B. levis*, only, in the fact that they both have smooth plates and bear eighteen arms. *B. levis* has no proboscis, this species has one, the form of calyx and vault is different and the structure of the radial series above the third primary radials is different, in the two species, as well as the regular and azygous areas. The two species cannot be mistaken for each other. It is hardly necessary to compare it with any other described species. It belongs to a long list of species having smooth or finely granular plates, but that is a feature of minor importance.

Found in the Burlington Group, at Burlington, Iowa. The specimen illustrated is in the collection of Mr. A. Albers; others are in the collection of S. A. Miller.

BATOCRINUS POLITUS, n. sp.

Plate I, Fig. 23, basal view; Fig. 24, azygous side; Fig. 25, summit view.

Species small, subglobose, vault not as large as the calyx, longitudinally constricted, on the azygous side. Calyx saucer shaped. Surface of the plates plane and smooth.

Basals form an hexagonal disc, with slightly re-entering angles, about twice as wide as the diameter of the column, and having an hemispherical depression for the insertion of the column. First primary radials nearly as long as wide, three hexagonal, two heptagonal. Second primary radials quadrangular, about twice as wide as long. Third primary radials a little larger than the second, pentagonal, axillary, and, in three of the rays, support, on each upper sloping side, two secondary radials, which gives to each of these rays two arms. In the ray on the left of the azygous area, the third primary radial bears upon the proximal side two secondary radials and upon the distal side a single secondary radial, which is axillary and supports, on each upper side, a tertiary radial, which arrangement gives to this ray three arms. In the ray on the right of the azygous area, the third primary radial supports, on the distal side, a secondary radial, which is axillary, and bears upon each upper side a tertiary radial; and on the proximal side two tertiary radials, the last one being axillary and supporting, upon one upper side, an arm, and upon the other a tertiary radial, which arrangement gives to this ray four arms. There are, therefore, thirteen arms in this species. The arm formula is 4+2+2+2+3.

There is only a single plate in each regular interradial area, and it is cut off from the vault by the secondary radials. In the azygous area there are five plates. The first one is in line with the first primary radials, longer and fully as large as either of them. It is followed by three plates, in the second range, the middle one of which is the smallest and much elongated. There is one elongated plate in the third range that rests upon the plate on the left of the second range and separates the middle plate, in the second range, from the secondary radials on the left, and extends up between the secondary radials and unites with the plates of the vault.

Vault highly convex, covered with rather large, polygonal, plain, smooth plates, and bearing a small, subcentral proboscis. The ambulacral openings are directed a little above a horizontal line, and may be seen in a summit view. No ovarian pores discovered.

This species bears little or no resemblance, in general form or surface features, to *B. hodgsoni*, the only thirteen-armed species heretofore described, and cannot be mistaken for it. Its nearest affinity seems to be with *B. dodecadaelylus*, Meek & Worthen, from which it is distinguished by having thirteen instead of twelve ambulacral openings to the vault, and one more secondary radial in one of the rays. This alone is sufficient to distinguish it as a species. It has also an extra, elongated plate, constituting the third range in the azygous area, that does not exist in *B. dodecadaclylus*. There are minor features in which they differ, but these constitute the essential differences. In describing *B. dodecadaclylus*, in Geo. Sur., Ill., Vol. II, p. 205, the third radials are described as "*hexagonal*." This is an accidental mistake, or typographical error, for they are all pentagonal in that species and in this one.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of S. A. Miller. It also occurs at Sagetown, Illinois, and is in the collection of F. A. Sampson, from that place.

BATOCRINUS GLABER, n. sp.

Plate I, Fig. 26, azygous view of a medium specimen; Fig. 27, opposite view of same; Fig. 28, opposite view of a large specimen.

Species varying in size from small to very large. Fig. 28 represents one of the largest specimens. Fig. 26 represents a medium-sized specimen. Others, among a collection of thirty specimens belonging to this species are not more than half as large as the medium-sized specimens. The vault is usually as long or longer than the calyx, but having somewhat less capacity. The calyx is somewhat saucer-shaped, constricted broadly at the first radials and rapidly rounding up to the ambulacral openings, which are directed upward at an angle of about forty-five degrees and are not visible in a basal view. Surface of the plates plain and smooth, occasionally the larger plates may show a slight convexity.

Basals form an hexagonal disc about one half wider than the diameter of the column, and bear a concave depression less than hemispherical, for its attachment. First primary radials wider than long and transversely concave, so as to give the appearance of a constriction of the calyx, at this place. Second primary radials quadrangular, two or three times as wide as long. Third primary radials a little larger than the second, three hexagonal and two heptagonal, axillary, and bear upon each of the two superior sides two secondary radials, the last ones being axillary and supporting, on each upper sloping side, two tertiary radials, which arrangement gives to each of the rays four arms. There are, therefore, twenty arms and twenty ambulacral openings to the vault, in this species. The arm formula is 4+4+4+4+4.

The regular interradial areas are quite different from each other. In one of the areas there are three plates, one, followed by two in the second range, which are cut off from the vault by the union of the first and second tertiary radials above them. In each of the other three regular interradial areas, there are four plates, one, followed by two in the second range, and by one in the third range, but the plates are more elongated in some of these areas than in others. In the largest specimens there is an additional plate in the third range, so that there are five plates in some of the areas and four in others. In the azygous area there are twelve plates. The first one is in line with the first primary radials and nearly as large. It is followed by three plates in the second range, four in the third range, three in the fourth range and one in the fifth range that separates the last tertiary radials. There is some difference in the plates, in the azygous areas, in different specimens, above the second range of plates, and the number in the areas seems to vary from eleven to thirteen. This is a feature that is noticeable in other species of *Batocrinus*, and it may be laid down as a rule that the number of azygous plates may vary, in the same species, but the number of ambulacral openings will not change, within the limits of a species, except as a result of injury or abnormal developments.

Vault conoidal and bearing a subcentral proboscis. It is covered with plain, smooth, polygonal plates. The ambulacral openings are directed above an horizontal line and are visible in a summit view. No ovarian pores have been discovered.

This species is essentially different in its structure and general form from all other twenty-armed species, and no comparison with any of them would tend to throw any light upon it. It is a species, however, that has been frequently mistaken for *B. rotundus*, just as *B. oblatus* and all other smooth species of *Batocrinus* have been. *B. rotundus*, as originally defined and illustrated, is a twenty-one-armed species. It is much smaller, as a general rule, than this species and never attains the size of the specimens illustrated, in figure 28, though it has one more arm, in the radial series. It never agrees in form with this species, nor does it possess as large a probocis. It is not constricted around the first primary radials, as this species is, nor does it possess the same form and number of plates in the azygous and regular interradial areas. The resemblance between the two species is more fanciful than real. The error probably arose in this way, Meek & Worthen, in describing *B. dodecadactylus*, (Geo. Sur. Ill. Vol. 2, p. 207), say: "Knowing that the number of arms sometimes varies to some extent, in different specimen of the same species of crinoids, we were at first inclined to think the form under consideration might be only a young specimens of *A. rotundus*, but on comparing it carefully with specimens of that species of the same size, we find they possess the usual number of arms (20) in all our specimens, and uniformly present the other differences mentioned." In writing the description of *B. dodecadactylus*, Meek did not have a single specimen of *B. rotundus* before him, but he had numerous specimens of this species, some of them as small as the species he was describing, and he had mistaken them for *B. rotundus*. In other publications, we find *B. rotundus* mentioned as twenty-armed species, and like other errors, when put in circulation it continues, because all authors do not take the time to correct it. Yandell & Shumard described and illustrated in the Geo. Sur. of Mo. a twenty-one-armed species under the name of *Actinocrinus rotundus*, now known as *Batocrinus rotundus*, which is a species very rare, in comparison with this species, at Burlington and the Illinois localities and when this species was confounded with it, the species was supposed to be very common, because two were included under one name. The statement, that "the number of arms sometimes varies to some extent, in different specimens of the same species of crinoids," we think is quite a mistake, if it refers to

variations of the rays within the calyx, which we think never take place, except as a result of injury, and, therefore, of abnormal development. If crinoids vary to "some extent," in this respect, in the same species, they may vary to a greater extent and all the species may be thrown into one, under any particular genus. This erroneous view seems to have been entertained by several of the earlier authors when they described the crinoids, by the ring of the plates, commencing at the basals and going upward, and of course placing less and less value upon each succeeding ring, and it has been perpetuated, especially among those who have never given the subject much attention. Prof. James Hall was correct in laying the stress he did upon the arm formula, as our study and observation has led us to believe.

The specimens illustrated are from the Burlington Group, at Burlington, Iowa. The large one is in the collection of Wm. F. E. Gurley, the smaller one in the collection of A. Albers. The species is numerously represented in all collections from the Burlington Group of Iowa and Illinois.

BATOCRINUS INSOLENS, n. sp.

Plate II, Fig. 1, azygous side; Fig. 2, opposite view.

Species medium or below medium size, biturbinate, calyx and vault subequal in form and capacity, and together subelliptical in outline. Calyx bowl-shaped, truncated below and rounded up toward the arms; no radial ridges; plates convex and the larger ones transversely nodose; diameter from one-third to one-half more than the height.

Basals form an hexagonal disc about one-half wider than the diameter of the column, with an hemispherical columnar cavity radiately furrowed. First radials large, about as long as wide, three hexagonal and two heptagonal. Second radials quadrangular, from two to two and a half times as wide as long. Third primary radials larger than the second, four hexagonal and one heptagonal, axillary, and, in the ray opposite the azygous area, supports on each upper sloping side, three secondary radials, which gives to this ray two arms. In the ray on the left of the azygous area, and in the left lateral ray, the third primary radials support, on each superior side, two secondary radials, the last ones of which are axillary and bear upon each superior distal side two tertiary

radials, and upon each proximal side a single tertiary radial, which gives to each of these rays four arms. In the right lateral ray, the third primary radial supports, on one side, two secondary radials the last being axillary and supporting on the outer side two tertiary radials and on the inner side only one; and on the other side a single secondary radial, which supports, on the distal side, three tertiary radials, and, on the proximal side two, which gives to this ray four arms. In the ray on the right of the azygous area, the third primary radial supports, on the side adjoining the azygous area, two secondary radials, the last being axillary and supporting on each upper sloping side a single tertiary radial; and on the side distant from the azygous area three secondary radials, but two of these are upon the proximal sloping side of the first, and, upon the superior side of the first, there is an intersecondary plate, while the distal side abuts the first tertiary radial, in the adjoining ray. This is the structure of the specimen illustrated and gives to this ray only three arms, but, we think this structure is abnormal, because this intersecondary plate is in the position of a tertiary radial and because there is a plate out of place at the top of the azygous area that we will again call attention to. Beside, we have another specimen belonging to this species, that happens to be injured so as not to disclose the whole structure of the ray, but there are four ambulacral openings, and, so far as preserved, the ray is like the one on the left of the azygous area. There are, therefore, in the specimen illustrated, only seventeen arms, but we believe, from the structure and evidences above mentioned, that one of the rays has suffered from an injury that produced an abnormal ray and that the species bears eighteen arms, and that the true arm formula is 4+4+2+4+4, instead of 3+4+2+4+4. We do not wish to be understood, however, as intimating that seventeen ambulacral openings to the vault, is an abnormal condition of a crinoid, on the contrary, seventeen may as well be normal as eighteen or any other number. It is the peculiar intersecondary plate and the peculiar plate at the top of the azygous area and the evidence afforded by another injured specimen, that lead us to think the specimen illustrated is abnormal. If the ray was an ordinary three-armed ray, we would say the specimen is normal and the species has only seventeen arms, and, if another specimen constructed, on the same plan, was found

bearing eighteen arms, we would say it is a distinct species. The number of ambulacral openings to the vault is of the greatest specific importance, but a crinoid, injured on any part of the body, might have been able to heal the wound, by an abnormal growth, restoration or intercalation of plates.

There are three plates, in each of three regular interradial areas, one followed by two. In the area on the right of the three-armed ray there are only two plates, one followed by another. If we are correct in supposing the specimen illustrated to be abnormal, from some injury, then the areas, probably, are all alike and have three plates, one followed by two. In the azygous area there are seven plates. The first one is in line with the first primary radials and larger than either one of them. It is followed by four plates in the second range, and two in the third range, one of which reaches the plates of the vault in the specimen illustrated. The first plate and the last plate may be abnormal in size, and the latter, to some extent, in position; for if the ray, on the right of the azygous area, in a normal condition bears four arms, then the azygous area is, probably, cut off from the vault, and the last plate shown in the illustration is much smaller than it appears to be in the specimen, and does not extend to the vault plates.

The vault is conoidal and terminates in a large subcentral proboscis. It is covered with numerous convex, polygonal plates.

This species has little or no resemblance in form to *B. cassedayanus* or *B. formaceus*, the only seventeen-armed species heretofore described, and seems to be as far removed from all eighteen-armed species, except possibly, *B. longirostris*; but it is so far removed from that species that no comparison will throw any light upon either of them.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of S. A. Miller.

BATOCRINUS SELECTUS, n. sp.

Plate II, Fig. 3, azygous side; Fig. 4, opposite view; Fig. 5, summit.

Species medium size. Calyx obconoidal, truncated only the size of the column. Plates smooth, no radial ridges. Arm openings directed upward and not visible in a basal view.

Basals form a cup about twice as wide as high. First radials the largest plates in the body, and nearly as long as wide, three hexagonal, two heptagonal. Second and third radials together much smaller than the first. Second radials quadrangular, three or four times as wide as long. Third radials a little larger than the second, pentagonal, axillary, and support upon each superior sloping side two secondary radials, the last ones being axillary and supporting upon each upper side two tertiary radials, except in the ray opposite the azygous area where the second secondary radial upon one side supports an intersecondary plate, and not an arm, which arrangement gives to this species nineteen arms. The arm formula is 4+4+3+4+4.

Regular interradial areas very unequal. One has six plates, another five, another four, and the other three. The one that has four plates has one in the first range, two in the second, and an elongated plate in the third, which reaches a vault plate. The other areas are cut off from the vault by the union of the tertiary radials. There are eleven plates in the azygous area. The first one is in line with the first primary radials, but somewhat smaller. It is followed by three plates in the second range, and five in the third range, the middle one being much the largest. There is one small plate on the right of the latter. The middle plate in the third range unites with an elongated plate that separates the tertiary radials and extends over upon the vault.

Vault depressed convex, covered with smooth, polygonal plates, and bears a subcentral proboscis. No ovarian pores.

The form of this species is altogether different from other nineteen-armed species, and cannot be mistaken for any other species.

Found in the Burlington Group, at Sagetown, Illinois, and now in the collection of Wm. F. E. Gurley.

BATOCRINUS ALBERSI, n. sp.

Plate II, Fig. 6, azygous side having the basal plates broken away; Fig. 7, basal view; Fig. 8, summit.

Species above medium size, trochiform. Calyx abruptly spreading, almost horizontally, from the region of the second and third primary radials. Surface of the plates plane and smooth, and generally very large, and the last radials project beyond the summit plates.

Basals broken away from our specimen. First primary radials longer than wide, three hexagonal, two heptagonal. Second and third primary radials together much smaller than the first. Second primary radials quadrangular, between two and three times as wide as long. Third primary radials a little larger than the second, four pentagonal, one hexagonal, axillary, and in the ray, on each side of the azygous area, support, on each upper sloping side, two secondary radials, the last being axillary, and supporting, on each upper sloping side, a single tertiary radial, except on one side where there are two, which gives to each of these rays four arms. In one of the lateral rays, the third primary radial supports, upon each upper side, two secondary radials, the last one, upon one side, being axillary, and supporting, upon each upper side, a tertiary radial, and the last one, on the other side, supporting, on one side, a tertiary radial, and upon the other, a free arm, which gives to this ray four arms. In the other lateral ray and in the ray opposite the azygous area, the third primary radials support, on one side, three secondary radials, and upon the other side, two secondary radials, the last one being axillary, and supporting, on each upper side, a tertiary radial, which arrangement gives to each of these rays three arms. There are, therefore, eighteen arms in this species. The arm formula is 4+3+3+4+4.

In each of two of the regular interradial areas there are two plates, one following the other. In each of the other two regular interradial areas, there are three plates, one followed by two, in the second range. In the azygous area there are seven plates. The first one is in line with the first primary radials and of about the same size. It is followed by three plates, in the second range, and by three plates, in the third range, which are cut off from connection with the plates of the vault by the union of the tertiary radials.

The vault is moderately convex and bears a large central proboscis. The interambulacral areas are concave and covered with smaller plates than those over the ambulacral canals. The plates are polygonal, quite variable in size, the smaller ones convex and the larger ones tumid. The ambulacral openings are visible in a summit view, but cannot be seen from a basal view, though they seem to be directed nearly horizontally. No ovarian pores discovered.

This species bears little or no resemblance, in form or surface ornamentation, to any other described eighteen-armed species. The calyx has some resemblance to that of *B. christyi*, which is a twenty-armed species, but, probably, looks more like *B inornatus*, another twenty-armed species, than to any other defined species. It is so widely separated from these, however, that no comparison is necessary for any purpose.

Found in the Burlington Group, at Burlington, Iowa. The specific name is in honor of Mr. A. Albers, the artist, and the type belongs to his collection.

BATOCRINUS SACCELLUS, n. sp.

Plate II, Fig. 9, azygous side; Fig. 10, opposite view; Fig. 11 summit.

Species medium or above medium size. Calyx urn-shaped, a little wider than high. Plates convex; no radial ridges. Sutures beveled. Surface granular.

Basals form a low hexagonal cup with beveled sutures and an hemispherical depression for the attachment of the column. The diameter is three times the height or twice the diameter of the column. The first primary radials are the largest plates in the body, and are nearly as long as wide. They are about as large as the second and third plates together. Three hexagonal and two heptagonal. Second primary radials quadrangular and from two to three times as wide as long. Third primary radials a little larger than the second, each one is heptagonal and supports on each of two of the upper sides, in four of the rays, two secondary radials the last ones of which are axillary and support, on each proximal upper side, a single tertiary radial, and on each distal side, two tertiary radials, which give to each of these rays four arms. In the ray opposite the azygous area, the third primary radial bears on one upper sloping side, three secondary radials, and upon the other, two secondary radials, the last being axillary and supporting, on each upper side a single tertiary radial, which gives to this ray three arms. There are, therefore, nineteen arms, in this species. The arm formula is 4+4+3+4+4.

The interradial areas are very different from each other; in each of the two areas there are four plates, one in the first range, two in the second and one in the third. In each of the other areas,

there are five plates; in one of them there are three plates, in the second range, and one in the third, and in the other there are two plates, in the second range, and two in the third. There are thirteen plates in the azygous area. The first one is in line with the first primary radials and about as large. It is followed by three plates in the second range, six plates in the third range, three plates in the fourth range, the middle one of which unites with a plate on the vault, and a small plate in the fifth range also unites with the plates of the vault. The plates in the regular areas are all distinctly cut off from the plates of the vault, except in one area, where a plate in third range extends an angle to a vault plate.

The vault is elevated abruptly over the ambulacral openings, and depressed convex toward the center, where it bears a strong proboscis. The interambulacral areas are depressed toward the margin. The plates are polygonal, convex, and some of the larger ones bear a central node. The arm openings are directed upward, at an angle of about forty-five degrees, and are not visible in a basal view. No ovarian pores have been discovered.

This species bears very little resemblance to any other nineteen-armed species and may have its nearest affinity with *B. longirostris*, a twenty-armed species. It has a different form, however, and a differently constructed vault, and differs widely in the regular and azygous areas, as well as being larger and having only nineteen arms. It cannot be mistaken for any other species.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of Wm. F. E. Gurley.

BATOCRINUS SUBLEVIS, n. sp.

Plate II. Fig. 12, azygous side; Fig. 13, opposite view; Fig. 14, summit.

Species large, somewhat biturbinate. Calyx truncated only the size of the column, broadly constricted in the region of the first primary radials, and rounding up toward the arm openings, which are directed upward and are not visible from a basal view. One-half or more than one-half wider than high. No radial ridges. Surface plain and smooth.

Basals form a low cup, about two and a half times as wide as high, which bears a hemispherical depression for the attachment of the column. First primary radials transversely concave, large, wider than long, three hexagonal and two heptagonal. Second primary radials quadrangular, about twice as wide as long. Third primary radials about one half larger than the second, three heptagonal and two hexagonal, and bear upon each of two of the superior sides two secondary radials, the last ones of which are axillary and, in four of the rays, support on each upper side two tertiary radials, which gives to each of these rays four arms. In the ray on the right side of the azygous area the distal secondary radial bears, upon each upper side, two tertiary radials, and the proximal secondary radial bears, upon one side, two tertiary radials and upon the other a single tertiary radial, which is axillary and bears, upon each upper side, a single quaternary radial, which arrangement gives to this ray five arms. There are, therefore, twenty-one arms in this species. The arm formula is 5+1+4+4+4+4.

In each regular interradial area there are six plates. One in the first range, two in the second, two in the third and one in the fourth, all of which are cut off from any connection with the vault, by the union of the tertiary radials. In the azygous area there are twenty-one plates. The first is in line with the first primary radials and of about the same size. It is followed by three plates in the second range, five plates in the third range, six plates in the fourth, and above these there are five small plates and one elongated plate that extends up to and unites with two plates belonging to the vault.

The vault is subconoidal and covered with irregular, polygonal plates, and bears a very large, subcentral proboscis. The plates are plain and smooth, except the large plate opposite to the azygous side of the proboscis, which is convex. The arm openings are directed upward. No ovarian pores discovered.

This species cannot be compared with any other twenty-one armed species, unless it is with *B. rotundus*, and here there is very little resemblance. The form of the calyx is different; there is no constriction in *B. rotundus*. The vault and proboscis are altogether different, in every respect. This species has twice as many regular interradials and twice as many azygous plates, and the areas are altogether different. It agrees with *B. glaber*, which is

a twenty-armed species, only in the smooth plates and the constriction at the first primary radials. It is quite unnecessary to make further comparisons, for it cannot be mistaken for any other species, where there is the slightest capacity for observation.

Found in the Burlington Group, at Sagetown, Illinois, and now in the collection of Wm. F. E. Gurley.

BATOCRINUS REMOTUS, n. sp.

Plate II, Fig. 15, azygous side; Fig. 16, opposite view; Fig. 17, summit.

Species medium size. Calyx obconoidal, a little wider than high, truncated only the diameter of the column. Ambulacral openings directed only slightly above a horizontal line, but not visible either in a basal or summit view. No radial ridges. Surface of the plates plain and smooth. Column round and composed of rather thick plates.

Basals form an obconical cup twice as wide as high. First primary radials one-half larger than the second and third together, nearly as long as wide, three hexagonal, two heptagonal. Second primary radials quadrangular, about twice as wide as long. Third primary radials very little larger than the second, pentagonal, axillary, and support, on each upper sloping side, two secondary radials, the last ones of which are axillary, and, in three of the rays, support, on each proximal side, a single tertiary radial, and upon each distal side, two tertiary radials, which gives to each of these rays four arms. In each ray adjoining the azygous area, the structure is the same, except the secondary radials bear upon each of the sides abutting the area a single tertiary radial, which is axillary, and supports, upon each upper side, a quaternary plate, which arrangement gives to each of these rays five arms. There are, therefore, twenty-two arms in this species. The arm formula is 5+4+4+4+5.

In each regular interradial area there are two plates, one followed by another, that does not extend to the vault. In the azygous area there are eight plates. The first one is in line with the first primary radials and rather larger than either of them. It is followed by four plates, in the second range, and by three plates, in the third range, which are cut off from the plates of the vault by the union of the quaternary plates above them.

The vault is covered with polygonal, convex plates, and bears a large, subcentral proboscis. It is elevated over the ambulacral openings and convex toward the proboscis, except a concave interambulacral depression on the azygous side. No ovarian pores discovered.

This species evidently has its nearest affinity with *Batocrinus turbinatus* and *Batocrinus turbinatus var. elegans*, with which it agrees, in the radial series. In *B. turbinatus*, the basal plates are thick, short, and form a distinct rim projecting over the column, and in the *var. elegans* the basal plates are squarely truncate below, and indented at the sutures. In this species the basal plates form an obconoidal cup entirely covered below by the end of the column. In the regular interradial areas, in *B. turbinatus* and in the *var. elegans*, there are three ranges of interradials, the last plate, in *B. turbinatus*, lying near the bases of the arms. In this species there are only two ranges of interradials and they are cut off from the arm bases by the union of the two series of tertiary radials above them. In *B. turbinatus* and in the *var. elegans*, there are only three plates, in the second range, in the azygous area, and, in this species, there are four plates. In *B. turbinatus* there are ten azygous plates, and the last ones separate the arm bases and unite with the plates of the vault. In this species there are only eight azygous plates and they are cut off from the vault by the union of the quaternary plates above them. There are important differences in the structure of the vault and minor variations might be pointed out, but the general expression of the species will always distinguish them; and, unless we wholly set aside any importance to the structure of the regular and azygous areas, intermediate forms cannot bring these forms into a single species, though the arm formulas bring them to a close relationship.

Found in the Burlington Group, at Burlington, Iowa and now in the collection of S. A. Miller.

BATOCRINUS REPOSITUS, n. sp.

Plate II, Fig. 18, azygous side; Fig. 19, opposite view; Fig. 20, summit.

Species medium size. Calyx obconoidal, nearly as high as wide, truncated only for a small column; last radials project laterally, while the interradial spaces are depressed and the ambulacral openings become invisible from a basal view. No radial ridges. Surface of the plates plain and smooth. Column small and round.

Basals form a conical cup, having a height nearly equal to the diameter, and it is truncated below by a small column. First primary radials not as large as the basals, wider than long, three hexagonal, two heptagonal. Second primary radials quadrangular, from two to three times as wide as long. Third primary radials a little larger than the second, one heptagonal, three hexagonal, one pentagonal, axillary, and in each of the rays, adjoining the azygous area, support on each upper sloping side two secondary radials, the last ones of which support, on each upper sloping side a single tertiary radial, except the distal one on the left, which bears an ambulacral opening on one side of the secondary radial and on the other a tertiary radial. The arrangement, however, gives to each of these rays four arms. In one of the lateral rays the third primary radial supports, upon each upper side, two secondary radials, the last ones having an ambulacral opening on each proximal side, and a tertiary radial on each distal side, which gives to this ray four arms. In the other lateral ray the structure is the same, except that one of the secondary radials does not bear a tertiary plate, but it supports two ambulacral openings, so that the ray has four arms. In the ray opposite the azygous area, the third primary radial supports, on one side, two secondary radials, the last one being axillary and supporting on each side a tertiary radial, and on the other side two secondary radials, the last one having a single ambulacral opening, which gives to this ray three arms. There are, therefore, nineteen arms in this species. The arm formula is 4+4+3+4+4.

The interradial areas are remarkable. The first one to the right of the azygous area has four plates, one in the first range, and two large, elongated plates in the second range, one of which, and a small plate at the side of the top of it, unite with two plates belonging to the vault. The lateral area, on the same side,

has three plates, one in the first range and two in the second, but they do not connect with the vault. The area opposite the azygous area has six plates, one in the first range, two in the second and three in the third, the middle one of which is large and elongated and extends over upon the vault. The other lateral area has five plates, one in the first range, two in the second and two in the third, which unite with two plates belonging to the vault. There is one intersecondary plate in the area to the right of the azygous area, and also in the opposite area, that unites with the plates of the vault. In the other intersecondary areas a vault plate curves down between the arm bases and unites with the secondary radials. In the azygous area there are eleven plates. The first one is in line with the first primary radials and quite as large. It is followed by three plates in the second range, four in the third range, above which there are three plates, the middle one passing up between the arm bases and uniting with the plates of the vault.

The vault is gently convex, covered with large and small polygonal plates, and bears a subcentral azygous orifice. The arm openings are directed upward. No ovarian pores discovered.

This is a remarkable species, and will not be mistaken for any other. The vault and interradial and intersecondary areas are peculiar, but the arm structure is the most extraordinary. The secondary radials that are half axillary, or bear a free arm on one side and a tertiary radial on the other, is a feature of rare occurrence, but it is certainly not abnormal. *Batocrinus bisbrachiatus*, Whitfield, of which we have several specimens, bears two free arms on each of the last radials, without the presence of the usual axillary plate, so that it is much farther removed from the ordinary arm structure than is this species.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of A. Albers.

BATOCRINUS EXODATUS, n. sp.

Plate II, Fig. 21, azygous side; Fig. 22, basal view; Fig. 23, summit.

Species small, subglobose, vault as large as the calyx, longitudinally constructed on the azygous side. Calyx saucer shaped. Surface of the plates plane and smooth.

Basals form an hexagonal disc, with slightly re-entering angles, more than twice as wide as the diameter of the column and having a concave depression for the attachment of the column. First primary radials wider than long, three hexagonal, two heptagonal. Second primary radials quadrangular, two or three times as wide as long. Third primary radials about one-half larger than the second, pentagonal, axillary, and in the ray, on each side of the azygous area, support, on each sloping side, a single secondary radial, which is axillary and supports, on each superior side, a tertiary radial, which gives to each of these rays four arms. In each of the other three rays the third primary radial supports, on each upper side, a single, large, secondary radial, which gives to each of these rays two arms. There are, therefore, fourteen ambulacral openings to the vault in this species. The arm formula is 4+2+2+2+4.

There is only a single plate in each regular interradial area, and it is cut off from the vault by the union of the secondary radials. In the azygous area there are four plates. The first one is in line with the first primary radials and somewhat smaller than either of them. It is followed by three plates in the second range, the middle one of which unites with an elongated plate that belongs to the plates of the vault.

Vault highly convex, covered with rather large, polygonal, plane, smooth plates, and bears a subcentral, azygous orifice, without a proboscis. Ambulacral openings directed above an horizontal line and not visible in a basal view. No ovarian pores discovered.

This species bears no resemblance, in form or surface ornamentation, to any other fourteen-armed species. It would seem to have the nearest affinity with *B. politus*, from which it is distinguished by having only one secondary radial instead of two, by having fourteen arms instead of thirteen, by having no proboscis, and other minor differences.

Found in the Burlington Group, at Sagetown, Illinois, and several specimens are in the collection of F. A. Sampson.

BATOCRINUS SPECIOSUS, n. sp.

Plate II, Fig. 24, azygous side; Fig. 25, opposite view; Fig. 26, summit.

Species medium size, biturbinate. Calyx obpyramidal, moderately truncated below, slightly constricted at the top of the basal disc, most rapidly spreading at the base of the arms, more than one-half wider than high. Radial ridges present. Surface of interradials smooth. Arm openings directed nearly horizontally.

Basals short, upright, and form an hexagonal disc. First primary radials the largest plates in the calyx, about as long as wide, three hexagonal, two heptagonal, and each one bears a small, central, transverse node. The constriction at the top of the basal disc involves the lower part of the first radials. Second primary radials quadrangular, two or three times as wide as long. Third primary radials hexagonal or heptagonal, about one-half larger than the second, axillary, and, in the ray opposite the azygous area, supports on each upper sloping side three secondary radials, which gives to this ray two arms. In each of the other four rays the third primary radial supports, on each upper sloping side, two secondary radials, the last ones being axillary and supporting on each upper sloping side two secondary radials, which gives to each of these rays four arms. There are, therefore, eighteen arms in this species. The arm formula is 4+4+2+4+4.

The interradial areas do not connect with the vault. In each regular interradial area there are three plates, one followed by two in the second range. In the azygous area there are seven plates. The first one is in line with the first primary radials and nearly as large as one of them. It is followed by three plates in the second range and three in the third, which are cut off from the vault by the union of the tertiary radials above them.

The vault is elevated over the ambulacral openings, highly convex, with slightly depressed interambulacral areas. It is covered with polygonal, convex plates, and bears a subcentral proboscis.

This is a handsome species, so different from all other eighteen-armed species from the Burlington Group, that no comparison with any of them is necessary.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of Mr. A. Albers.

BATOCRINUS SUBROTUNDUS, n. sp.

Plate II, Fig. 27, basal view; Fig. 28, summit; Fig. 29; azygous side.

The general form is depressed rotund. The vault being as large or larger than the calyx, and both slightly depressed longitudinally at the margin at the top of the azygous area. Calyx broadly saucer-shaped. No radial ridges. Arm openings directed above an horizontal line and not visible in a basal view. Surface plain and smooth.

Basals expanded and forming a shallow, hexagonal disc, about twice as wide as the diameter of the column and bearing an hemispherical depression for the attachment of the column. First primary radials from one-half wider to twice as wide as long, three hexagonal and two heptagonal. Second primary radials quadrangular, about three times as wide as long. Third primary radials as small as the second, pentagonal, axillary, and in the ray on the right of the azygous area supports on each upper sloping side two secondary radials, the last ones being axillary and supporting on each proximal side two tertiary radials and on each distal side a single, axillary, tertiary radial which supports on each upper side a quaternary radial, which arrangement gives to this ray six arms. In the ray, on the left of the azygous area, the third primary radial supports on each upper sloping side a single, axillary, secondary radial, which bears on each proximal side two tertiary radials and on each distal side two tertiary radials, the last ones being axillary and supporting, on each upper sloping side, a quaternary radial, which gives to this ray six arms. In the ray opposite the azygous area, the third primary radial bears, upon one side, two secondary radials, the last being axillary and supporting, on each upper side, two tertiary radials, and upon the other side, a single secondary radial, which is axillary and supports, on one side, two tertiary radials, and, upon the other, three tertiary radials, which gives to this ray four arms. One of the lateral rays is constructed in the same way and has four arms. The other lateral ray bears upon each upper side of the third primary radial two secondary radials, the last ones being axillary and supporting, on each upper sloping side, two tertiary radials, which gives to it four arms. There are, therefore, twenty-four arms in this species. The arm formula is 6+4+4+4+6.

The regular interradial areas differ from each other, but none of them connect with the plates of the vault. In each of two areas there are three plates, one followed by two in the second range. In another area there are four plates, one followed by two in the second range, and one in the third range. In the other area there are five plates, one followed by two in the second range, one in the third range and one in the fourth range. There are nine plates in the azygous area. The first one is in line with the first primary radials, and rather larger than either of them. It is followed by four plates in the second range, and three in the third range, above which there is a single plate that separates the quaternary radials and unites with the plates belonging to the vault.

The vault is very evenly convex and bears a subcentral azygous orifice. No proboscis. It is covered with plane, smooth, polygonal plates. No ovarian pores discovered.

This species bears no resemblance in form to either of the twenty-four-armed species heretofore described. It would be classed with the rotund forms having smooth plates and no proboscis and ranging from *B. dodecadactylus* with twelve arms to the present species.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of A. Albers.

BATOCRINUS SUBOVATUS, n. sp.

Plate II, Fig. 30, azygous side; Fig. 31, opposite view.

Species medium size, and general form rotund or subovate; calyx and vault subequal in size. No radial ridges. Plates plane and smooth. Arm openings directed above an horizontal line and not visible in a basal view.

Basals form an hexagonal disc a little larger than the diameter of the column, which bears a concave depression for the attachment of the column. First primary radials about one half wider than high, three hexagonal, two heptagonal. Second primary radials quadrangular, two or three times as wide as long. Third primary radials a little larger than the second, pentagonal, axillary, and the ray on the right of the azygous area bears upon each superior sloping side two secondary radials, the last being axillary, and one of which bears upon each upper face two tertiary radials, and the other bears upon the distal side, two tertiary radials, and upon the proximal side, one axillary, tertiary radial, which supports upon each upper side a quaternary radial, which gives to this ray five arms. In the ray on the left of the azygous area, the third primary radial bears upon each upper side, two secondary radials, the last being axillary and supporting, upon each upper side, two tertiary radials, which gives to this ray four arms. In one of the lateral rays, the third primary radial bears upon one side four secondary radials, and upon the other, three secondary radials, the last being axillary and supporting on each upper side two tertiary radials, which gives to this ray three arms. In the other lateral ray, the third primary radial supports, on one side, three secondary radials, and upon the other, one which is axillary and supports, on one side, three tertiary radials, and on the other, two tertiary radials, which gives to the ray three arms. In the ray opposite the azygous area the third primary radial supports, on

each upper side, three secondary radials, which gives to it two arms. There are, therefore, seventeen arms in this species. The arm formula is 5+3+2+3+4.

The interradial areas are unequal, but all are separated from the plates of the vault. In each of two areas there are two plates, one following the other. In another area there are three plates, one followed by two in the second range. In the other area there are four plates, one followed by two in the second range, and one in the third range. There are eight plates in the azygous area. The first one is in line with the first primary radials and somewhat smaller than either of them. It is followed by three plates, in the second range, three in the third range, and one in the fourth range, which is cut off from the vault by the union of the tertiary radials above it.

The vault is highly convex and covered with plane, smooth, polygonal plates. It bears a subcentral proboscis. No ovarian pores discovered.

This species bears little resemblance to any other seventeen armed species, and, of course, need not be compared with any other; though its general appearance may be said to resemble *B. rotundus*, from which it is very widely separated in the essential elements of structure.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of A. Albers.

BATOCRINUS SUBSCITULUS, n. sp.

Plate III, Fig. 9, view opposite the azygous area; Fig. 10, basal view; Fig. 11, summit.

Species medium size, biturbinate, or somewhat wheel-shaped. Calyx two and a half times as wide as high, most rapidly spreading toward the arms, which are directed horizontally, and leaving the sides concave or a broad constriction from the basals to the arms. Surface of the plates plain and smooth.

Basals form a low expanding cup twice as wide as the diameter of the column and having an hemispherical depression for the attachment of the column. First primary radials between two and three times as wide as long, three hexagonal, two heptagonal. Second primary radials quadrangular, three or four times as wide as long. Third primary radials only a little larger than the second, three hexagonal, one heptagonal and one pentagonal, axillary, and in each of four of the rays support, on each superior sloping

side, two secondary radials, the last being axillary, and supporting, on each upper side, two tertiary radials, except adjoining the azygous area there are three, which gives to each of these rays four arms. In the ray opposite the azygous area, the third primary radial bears upon each upper sloping side three secondary radials, which gives to this ray two arms. There are, therefore, eighteen arms in this species. The arm formula is 4+4+2+4+4.

In each regular interradial area there are three plates, one wide, short plate, followed by two in the second range. In the azygous area there are seven plates. The first one is in line with the first primary radials and about the same size. It is followed by three plates, the middle one being short and very wide; above these upon the right there are three small plates, in the third range. The azygous and interradial areas are widely separated from the plates of the vault.

The vault is convex and covered with large, polygonal, tumid plates. It bears a subcentral proboscis.

This species is so readily distinguished by its general form and surface characters from all other eighteen-armed species that no comparison is necessary with any of them.

Found by R. A. Blair in the Burlington Group, at Sedalia, Missouri, and now in the collection of S. A. Miller.

BATOCRINUS RUDIS, n. sp.

Plate IV, Fig. 4, azygous side view.

Species large, biturbinate. Calyx about one-half wider than high, most rapidly spreading in the superior part, so as to leave the sides arcuate or apparently broadly constricted from the basals to the free arms. Ambulacral openings directed horizontally and not visible in a basal or summit view. Plates tumid and nodose. No radial ridges.

Basals the largest plates in the body, flattened on the outside and extended in expanding wedge-shaped ends below the end of the column. They form an hexagonal cup, about twice as wide as the diameter of the column, with widely gaping sutures below, so that the calyx will stand on the cuneiform edges of the basal plates. First primary radials wider than long, three hexagonal, two heptagonal, and each one bears a transverse central node. Second primary radials quadrangular about one-half or less than one-half wider than long and each one bears a central node. Third primary radials of unequal size, the one on the right of the azygous area is large and heptagonal, the one on the left

of the azygous area is small and hexagonal, the others are pentagonal or hexagonal, axillary, and support, on each upper sloping side, two secondary radials, the last being axillary, and supporting, upon each upper sloping side, two tertiary radials, except on each side adjoining the azygous area, where there is only a single secondary radial, which is axillary, and bears upon each superior sloping side three tertiary radials, which arrangement gives to each ray four ambulacral openings to the vault. There are, therefore, twenty arms and twenty ambulacral openings to the vault in this species.

The regular interradial areas are widely separated from the plates of the vault, and in the areas that can be determined in our specimen there are three plates, one, followed by two small ones in the second range. In the azygous area there are seven nodose plates. The first one is in line with the first primary radials and larger than either of them. It is followed by three plates in the second range, two in the third range, and one in the fourth range that unites with an elongated plate belonging to the vault.

The vault is highly convex or conoidal and has a capacity fully equal to that of the calyx. It is covered with very tumid and nodose plates, and bears a very large central proboscis.

This species is readily distinguished by its form and nodose plates from all others that have been described, among the twenty-armed species. Probably it is as near *B. honorabilis* as any other, but there are more tertiary radials in that species than in this one, and the ambulacral openings are directed upward instead of horizontally. The interradial areas are more elongated and have more ranges of plates than there are in this species, and the azygous area is is not connected with the vault in that species as it is in this. The vault is much more conoidal in this species than in that, and has a much larger proboscis. The two species are so dissimilar that they are readily distinguished.

Found in the Keokuk Group, on Little Barren river, Kentucky, and now in the collection of Charles L. Faber.

BATOCRINUS SAGETOWNENSIS, n. sp.

Plate IV. Fig. 5, azygous side: Fig. 6, opposite view: Fig. 7, summit.

Species large, somewhat urn-shaped. Calyx somewhat obconoidal, nearly as long as wide, broadly truncated, constricted above the basals, lobed in the superior radial regions. Plates convex, the larger ones nodose. Ambulacral openings directed upwards and not visible in a basal view.

Basal plates the largest in the body, and form a cup about twice as wide as high and about twice as wide as the diameter of the column. They extend below the end of the column and are constricted in the upper part. First primary radials large, longer than wide, three hexagonal, two heptagonal, and each one bears a transverse central node. Second primary radials quadrangular, about one-half wider than long. Third primary radials a little larger than the second, pentagonal, axillary, and support, on each upper sloping side, two large, secondary radials, the last being axillary and supporting, on each upper sloping side, a single, large tertiary radial, which arrangement gives to each ray four ambulacral openings to the vault. There are, therefore, twenty ambulacral openings to the vault in this species.

All of the interradial areas connect with the plates of the vault. The regular interradial areas are elongated, of unequal size, and contracted toward the superior part. The first plate in each of the areas is large and nodose. In one area there are two plates in the second range, one in the third range, and one in the fourth range, which unites with a single plate belonging to the vault. In another area there are two elongated plates, in the second range, that unite with two elongated plates, that curve over upon the vault. In another area there are two plates, in the second range, that unite with two plates, in the third range, that unite with two plates belonging to the vault. The other area has the same number of plates that are in the first area, above described, and they are arranged in nearly the same order, dut differ in size. There are eleven plates in the azygous area. The first one is in line with the first primary radials, and of about the same size and equally as nodose. It is followed by three plates, subequal in size, in the second range. In the third range there are four plates, one of which is quite small and quadrangular, and above it and in line with the upper part of the largest plate, in the

third range, there is a single plate. Above the last two plates there are two elongated plates that unite with the plates of the vault.

The vault recedes from the ambulacral openings with slight convexity, and then rapidly rises cone like, which is continued slightly, subcentrally, in a large proboscis. The vault is covered with polygonal, convex plates, the larger ones being nodose. The ambulacral openings are above the calyx, on the flattened margin of the vault, and are directed straight upward.

This is a peculiar species, so different in its general appearance and structure from all other twenty-armed species, that no comparison with any of them is necessary to distinguish it.

Found in the Burlington Group, at Sagetown, Illinois, and now in the collection of Wm. F. E. Gurley.

BATOCRINUS AFFINIS, n. sp.

Plate IV, Fig. 8, azygous view; Fig. 9, opposite view.

Species small, somewhat biturbinate. Calyx obconoidal, truncated, nearly as high as wide. No radial ridges. First primary radials and interradials nodose. A small ovarian pore by the side of each ambulacral opening. Ambulacral openings directed horizontally.

Basals form an hexagonal cup four times as wide as high, twice as wide as the diameter of the column, slightly constricted in the upper part, and having an hemispherical depression for the attachment of the column, and a minute, round columnar canal. First primary radials longer than wide, three hexagonal, two heptagonal, and each one bears a central node. Second primary radials quadrangular, twice as wide as long, and with the third primary radials smaller than the first. Third primary radials about twice as large as the second, one hexagonal, four pentagonal, axillary, and in the ray on each side of the azygous area the distal side supports two secondary radials and the proximal side a single axillary secondary radial, which supports, on each upper side, a single tertiary radial, which gives to each of these rays three arms. In each of the other three rays the third primary radial supports, on each upper sloping side, two secondary radials, which gives to each of these rays two arms. There are, therefore, twelve arms in this species. The arm formula is 3+2+2+2+3.

There is only one regular interradial plate in each area, and it is below the secondary radials and bears a central node. There are six plates in the azygous area. The first one is in line with the first primary radials, and fully as large as either one of them. It bears a central node and is followed by three plates in the second range. A small plate is intercalated on the left of the middle plate, and an elongated plate follows the middle plate of the second range and unites with the plates of the vault. The calyx is longitudinally depressed in the superior part of this area.

The vault is convex, covered with convex, polygonal plates, and bears a subcentral proboscis. It is depressed toward the azygous area.

This species will not be mistaken for any other twelve-armed species. Its affinity seems to be, through *B. approximatus*, with *B. verneuilianus*. The proboscis may be smaller, the interradial and azygous areas somewhat different and there may be other minor differences, but the essential difference is in the arm formula. *B. approximatus* has thirteen ambulacral openings to the vault, *B. verneuilianus* has fourteen ambulacral openings to the vault, and this species has only twelve.

Found in the Burlington Group, at Sagetown, Illinois, and now in the collection of Wm. F. E. Gurley.

BATOCRINUS APPROXIMATUS, n. sp.

Plate IV, Fig. 10, azygous side of an elongated form; Fig. 11, opposite view of the same; Fig. 12, lateral view of a broader form.

Species below medium size, somewhat biturbinate. Calyx obconoidal, from one fourth to three fourths wider than high. No radial ridges. First primary radials and interradials varying from smooth to nodose. An ovarian pore by the side of each ambulacral opening. Ambulacral openings directed horizontally.

Basals form a round cup from two to three times as wide as high and about one-half wider than the diameter of the column. Plates beveled to the column, which is attached in an hemispherical depression. First primary radials nearly as long, or as long, as wide, three hexagonal, two heptagonal, some are nodose and others are smooth. Second and third primary radials together much smaller than the first. Second primary radials quadrangular, about twice as wide as long. Third primary radials a little larger than the second, pentagonal, axillary, and in the ray on

each side of the azygous area the distal side supports two secondary radials and the proximal side an axillary secondary radial which supports, on one upper sloping side, two tertiary radials and, upon the other, one, which gives to each of these rays three arms. One of the lateral rays on the right side of some specimens and upon the left side of other specimens is constructed in the same way, and bears three arms. In each of the other two rays the third primary radial supports, on each upper sloping side, two secondary radials, which gives to each of these rays two arms. There are, therefore, thirteen arms in this species. The arm formula is 3+3+2+2+3, or 3+2+2+3+3.

In the elongated specimens there is only one regular interradial in each area, and it is below the secondary radials, but in the broader forms, in some of the areas, there is an additional plate that separates the secondary radials, in one or more of the areas, and unites with the plates of the vault. There are nine plates in the azygous area, in the elongated specimens. The first one is in line with the first primary radials and of about the same size. It is followed by three plates in the second range, three in the third range, and two in the fourth range that unite with the plates of the vault. In the shorter forms there are only eight plates in the azygous area.

The vault is much more convex or conical in the elongated specimens than in the broader forms and it bears a nearly central proboscis.

This species will not be mistaken for any other thirteen-armed species. Its affinities are with *B. affinis* above described and *B. verneuilianus*. The basals form an hexagonal cup in *B. affinis;* horizontally truncated below, a round cup, in this species, beveled to the column, and a round cup, with a band at the bottom in *B. verneuilianus*. There are more azygous plates in this species than there are in *B. affinis*, and as many as there are in *B. verneuilianus*. But the difference, which we regard as most important, is found in the number of ambulacral openings to the vault. We think the difference in form and in the regular and azygous areas would not be of specific importance, without a corresponding difference in the arm formula.

Found in the Burlington Group at Burlington, Iowa. The specimens illustrated are in the collection of A. Albers, but both forms are also in the collection of S. A. Miller, and in that of Wm. F. E. Gurley.

BATOCRINUS VARIABILIS, n. sp.

Plate IV, Fig. 13, azygous side of a regular elongated specimen; Fig. 14, side view of same showing a four-armed ray; Fig. 15, showing a four-armed lateral ray and two plates in the regular interradial areas; Fig. 16, showing a four-armed ray, on the left of the azygous area; Fig. 17, showing a four-armed ray on the right of the azygous area.

Species variable in size, from small to medium; somewhat biturbinate, but varying in this respect. Calyx obconoidal, about one-half wider than high. No radial ridges. First primary radials and interradials varying from plane to nodose. Ambulacral openings directed nearly horizontally and an ovarian pore by the side of nearly every one of them.

Basals form a round cup, about three times as wide as high; it is slightly beveled to the column, which is about two-thirds the diameter of the cup. First primary radials usually as long as wide, three hexagonal, two heptagonal. Second and third primary radials together smaller than the first. Second primary radials quadrangular, about twice as wide as long. Third primary radials a little larger than the second, pentagonal, axillary, and in the specimen represented by figures 13 and 14, the one on each side of the azygous area bears upon the distal side two secondary radials and upon the proximal side a single, axillary secondary radial which bears upon each sloping side two tertiary radials, which gives to each of these rays three arms. The left lateral ray is constructed in the same way, except there is only a single tertiary radial where the other rays have two, and it has, therefore, three arms. In the right lateral ray, as shown in figure 14, there is a single, axillary, secondary radial, on each side of the third primary radial, which bears upon each upper sloping side, a single tertiary radial, which gives to this ray four arms. In the ray opposite the azygous area, the third primary radial bears upon each upper sloping side two secondary radials, which gives to it two arms. There are, therefore, fifteen arms in this species. The arm formula, in the specimen represented by figures 13 and 14, is 3+4+2+3+3. The specimen represented by figure 15 is constructed in the same way, except the left lateral ray has four arms, and the arm formula is 3+3+2+4+3. The specimen represented by figure 16, has the ray on the left of the azygous area bearing four arms, and the arm formula is 3+3+2+3+4. The

specimen represented by figure 17 has the ray on the right of the azygous area bearing four arms, and the arm formula is 4+3+2+3+3. It will be noticed that throughout all these variations the ray opposite the azygous area has two arms, and the four-armed ray changes its position to each of the other rays.

There is only a single plate in each of the four regular interradial areas in the specimens represented by figures 13, 14 and 16. And there are two plates in each of the regular interradial areas, in the specimens represented by figures 15 and 17. In the azygous area, in the specimen represented by figure 13, there are six plates. The first one is in line with the first primary radials and as large as either one of them. It is followed by three plates in the second range, subequal in size, and above these, there are two plates, one of which unites with the two plates belonging to the vault. The specimen represented by figure 17 has the same number of plates in the azygous area, but there is a little difference in the arrangement of the plates at the upper part of the area.

The specimen represented by figure 16 has seventeen plates in the azygous area. There are two small plates instead of one in the third range.

The vault is more convex in some specimens than in others. the proboscis is larger in some specimens than in others. The number and arrangement of the plates covering the vault is quite different in different specimens, as shown in figure 14 and 17.

Notwithstanding all these variations, we place all these forms in the same species, because, in each one, the number of ambulacral openings to the vault is the same. Other differences might be pointed out from other specimens, as, for example, some specimens have a single plate, in some of the regular interradial areas, and two in others, but those pointed out are the controlling variations.

There has never been but one fifteen-armed species heretofore described, from the Burlington Group, and it has no resemblance to this one. The affinities of this species are with *B. verneuilianus* and the two species are to be distinguished by the number of ambulacral openings to the vault. We have examined several hundred specimens of *B. verneuilianus*, and, while they differ in size, form and regular and azygous areas as much as the species here under consideration, they always have fourteen ambulacral openings to the vault. When Shumard described *B. verneuilianus*, he called it an *Actinocrinus*, because the genus *Batocrinus* was then unknown, and following the ordinary structure of *Actinocrinus*, in his definition, he said there were only two plates, in

the second range, in the azygous area, but there are three. He described the fourteen-armed species and gave the localities where it has been found in abundance; but, he said, "the number of arm-openings, in the specimens under examination, varies from fourteen to fifteen." He probably had some specimens of this species, which he did not distinguish from *B. verneuilianus*. But twenty specimens of that species are found in Missouri, Iowa and Illinois to where one is found belonging to this species, and there can be no doubt about which one he regarded as the type of his species.

Found in the Burlington Group, in Iowa, Missouri and Illinois, and in all good collections from that Group. Three of the specimens illustrated are in the collection of S. A. Miller and one in the collection of A. Albers.

BATOCRINUS COGNATUS, n. sp.

Plate IV, Fig. 18, azygous side, a three-armed ray on the right and a four-armed ray on the left; Fig. 19, four-armed ray on the right lateral side of same specimen; Fig. 20, four-armed ray on the left of the azygous area in another specimen; Fig. 21, a four-armed ray and three plates in an interradial area.

Species variable in size from small to medium; somewhat bitarbinate, but varying in this respect. Calyx obconoidal, about one-half wider than high. No radial ridges, but arms more or less clustered at the margin. Ambulacral openings directed nearly horizontally and an ovarian pore by the side of nearly every one of them.

Basals form a round cup about four times as wide as high; it is slightly beveled to the column, which is about two-thirds the diameter of the cup. First primary radials usually wider than long, three hexagonal, two heptagonal. Second and third primary radials together not larger than the first. Second primary radials quadrangular, two or two and a half times as wide as long. Third primary radials about twice as large as the second, pentagonal in such forms as are represented in Figures 18 and 19, but hexagonal, in part of the rays, in such forms as are represented by figures 20 and 21, axillary, and in the ray opposite the azygous area, supports, on each upper sloping side, two secondary radials, which gives to this ray two arms. In the specimen represented by Figures 18 and 19, in the ray on the left of the azygous area,

the third primary radial supports, on each upper side, a single, axillary, secondary radial, which supports, on each upper sloping side, two tertiary radials, except in one of the middle branches there is only one tertiary radial, which gives to this ray four arms. The ray, on the right lateral side, is constructed in the same way, except each of the proximal branches bears only a a single tertiary radial, and it has four arms. The ray on the right of the azygous side bears, on the distal side of the third primary radial, two secondary radials, and, on the proximal side, two secondary radials, the last one being axillary, and supporting, on each upper side, two tertiary radials, which gives to this ray three arms. The left lateral ray is constructed in the same way, except there is one less secondary radial and it bears on one side two tertiary radials and on the other, one; it has three arms. There are, therefore, sixteen arms in this species. The arm formula, in such specimens as are represented by Figures 18, 19 and 21, is 3+4+2+3+4. But in the specimen represented by Figure 20, the arm formula is 3+3+2+4+4.

In the specimen represented by Figures 18 and 19, there are two plates in one of the regular interradial areas and one in each of the others. In the specimen represented by Figure 20, there is one plate in one of the areas and two in each of the others. In the specimen represented by Figure 21, there are three plates in each of two areas and two plates in each of the others. In the azygous area there are eight plates. The first one is in line with the first primary radials and of about the same size. It is followed, in the second range, by three plates, and these by three plates, in the third range, above the middle one of which rests a single plate that unites with the plates of the vault. In one specimen we notice an additional small plate above the third range. The area is much more depressed between the rays in some specimens than in others.

The vault is more convex in some specimens than in others. In the spreading forms shown by Figure 21, the vault is only moderately convex, while in the biturbinate forms shown in Figure 18, the vault is conical; the proboscis is proportionally much smaller, in the spreading forms, than in the biturbinate.

It will be noticed that the variations in shape, and in the regular interradial areas, are as great in this species as they are in *B. variabilis*, and it is probable that other specimens may show another variation, in the arrangement of the arms; that is, a four-armed ray, on each side of the azygous area, and a three-armed ray on each lateral side. As a matter of course the affinities of

this species are with *B. variabilis*. It will be noticed that the ray opposite the azygous area has two arms in *B. affinis*, *B. approximatus*, *B. verneuilianus*, *B. variabilis* and *B. cognatus*. The different species have respectively twelve, thirteen, fourteen, fifteen and sixteen ambulacral openings to the vault, but, in all the changes, one of the rays remains the same. Here is the greatest and best defined evolution, through five species, that has ever been found among the palaeozoic crinoids. In *B. verneuilianus*, the two-armed ray sometimes changes place with the right lateral ray and sometimes with the left lateral ray, otherwise it is always opposite the azygous area. Suppose we were to throw all these species into one, as an illiterate and inexperienced pretender might do, what would be the result? It would simply wipe out all specific characters belonging to *Batocrinus*; for, if the arm formula, within the calyx, is not of specific importance, there is no specific character found in the genus, and if all these five species can be dumped into one species, all the rest may be made to follow. This is not indicating that these five species are not closely related, for we think they are. They have a wide geographical range, and are represented by numerous specimens, at many localities. What we think is, that here is an evidence of evolution of species, accompanied with varietal changes in each species, which tends to prove that one species arose from another, or might have arisen from another. We have no idea which species came first into existence or from whence it came. It may have been that from the twelve armed species arose all the others, or it may have been that the commencement was from the fourteen-armed species, and, that, by evolution, rays were gained in one direction and lost in another. If the more numerously rayed species were to be regarded as the more highly developed, it would be taking for granted, as a fact, that which the fossils do not prove and that which we have no right to assume, no matter what emphasis we may place on the number as a test of specific importance. We have not used the word *Eretmocrinus*, for the species under consideration are true *Batocrinus*.

The specimens illustrated are from the Burlington Group, from Burlington, Iowa, and from the collections of A. Albers and S. A. Miller, but others occur in all large collections, for the species is not rare.

BATOCRINUS CONSANGUINEUS, n. sp.

Plate IV, Fig. 22, azygous view; Fig. 23, opposite side.

Species about medium size, somewhat biturbinate. Calyx obconoidal, most rapidly spreading in the superior part so as to appear broadly constricted in the middle part; truncated below. No radial ridges. Ambulacral openings directed nearly horizontally, but not visible in a basal view, though they may be seen, in part, from the summit view. Plates plane, in our specimen, though the larger ones may be nodose in other specimens. A few ovarian pores only are distinguished in our specimen, but, probably there is one to each ambulacral opening. The diameter of the calyx is about one-half more than the height.

Basals form a rounded cup about one-third as high as wide, and very gradually spreading from the column. The columnar pit is hemispherical and it is rather sharply rounded at the margin to the outer side of the cup. First primary radials wider than long, three hexagonal, two heptagonal. Second and third radials together smaller than the first. First primary radials, quadrangular, between two and three times as wide as long. Third primary radials very little larger than the second, one hexagonal, the others heptagonal, axillary, and supporting on each superior sloping side two secondary radials, the last ones being axillary and supporting on each upper side a single tertiary radial, which gives to each ray four arms and four ambulacral openings to the vault. There are, therefore, twenty arms to this species. The arm formula is 4+4+4+4+4.

In one of the regular interradial areas there are three plates, one followed by two, in the second range. In another area there are four plates, one followed by two in the second range, and one in the third range. In another area there are five plates, one followed by two in the second range, and two in the third range. In the other area there are six plates. These areas are all cut off from the plates of the vault by the union of the tertiary radials, excepting the one having six plates, and one of these extends to the vault. In the azygous area, there are nine plates. The first one is in line with the first primary radials and of about the same size. It is followed by three plates in the second range, three in the third range, one on the right of the top of the middle plate in the third range, and one following the middle plate and uniting with two plates belonging to the vault. There is one plate in one of the intersecondary areas.

Vault moderately convex, covered with numerous polygonal plates and bearing a small subcentral proboscis.

This species does not seem, by its general form and structure, to be nearly related to any other twenty-armed species, and it cannot be mistaken for any of them. In its general form and surface characters, it seems to be related to *B. affinis*, *B. approximatus*, *B. verneuilianus*, *B. variabilis* and *B. Cognatus*. Indeed, were it not for the number of arms, it might be mistaken for either one of them. The variable character of the regular interradial areas reminds one of *B. variabilis*, *B. verneuilanus* and *B. cognatus*, and if we had other specimens, we might expect to find great differences, in this respect, in different specimens, and, probably, also, in the azygous areas. The one thing, only, that would stand to distinguish the species would be the number of arms. That is all the distinguishing specific character we discover now, though we have only a single specimen of this species, while we have hundreds of the others. We have not discovered any eighteen-armed species in this line of evolution of species, but we expect it will be found. We have a nineteen armed specimen but it is abnormal and may have resulted from some unknown injury to a fifteen, sixteen, or twenty-armed species or an ununknown eighteen or nineteen-armed species. We figure it below.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of A. Albers.

AN ABNORMAL SPECIMEN.

Plate IV, Fig. 24, right side view; Fig. 25, adjoining side view.

The general form of the specimen here illustrated is that of the last five above described species and their kindred, *B. verneuilianus*. It belongs to one of those six species or to an unknown eighteen or nineteen-armed species. The basal plates appear to be normal and so do four of the first primary radials, and the first azygous plate, followed by three plates, in the second range. Otherwise the plates of the calyx are not in a normal position, though the specimen appears to have been fully developed, has nineteen ambulacral openings to the vault and supports a large proboscis.

The first primary radial opposite the azygous area is a small axillary plate, and may be seen on the left of figure 25. On one of its upper sloping sides there are two plates in an interradial position, and on the other sloping side there are three primary radial plates, the last one being axillary, and supporting on each

upper side, a secondary radial, which bears an ambulacral opening, and if this were all, the ray would bear two arms, and the specimen would not belong to a twenty-armed species. But the second plate, in the series of three, is axillary and if the ray were straightened it would be the third primary radial, and the ray would have four arms. This may be seen on the left of figure 25 and on the right of figure 24, as the two figures may be put together, with a slight overlapping. However, when you look at figure 24 you can see, on the right, the series of three radial plates, apparently occupying an interradial position, and a radial series running off to the right that looks as if it might be the support of the two ambulacral openings that we have just given to the ray opposite the azygous area. This leaves in doubt the question whether the ray opposite the azygous area, in the normal condition, had two ambulacral openings or four. If it had four the species possessed, probably, twenty arms. Looking at figure 24, you will see three ambulacral openings above an interradial area. If the ray were straightened and the two ambulacral openings, on the right, given to the ray opposite the azygous area, the ray would take these three openings above the interradial area, and the ray would then have five arms. Probably this is where the specimen is dwarfed and the two openings, on the left, should be crowded over to the next ray, and the single opening should be represented by two openings, and then there would be twenty arms, in the species. If, however, this belonged to *B. consanguineus*, then the species was as variable in form, as we have found *B. variabilis* and *B. cognatus* to be. As a matter of course, where ambulacral plates are over interambulacral areas, the ambulacral canals curved so as to unite the circulation through the regular ambulacral channels. From the appearances, we are inclined to believe that this specimen belongs to a twenty armed species, and certainly, in a normal condition, possessed as many as nineteen arms. The injury or abnormal development did not, as we think, increase the number of ambulacral openings to the vault, the tendency, if in any direction, would be to decrease them.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of S. A. Miller.

ANOTHER ABNORMAL SPECIMEN.

Plate IV, Fig. 26, azygous side; Fig. 27, opposite view.

The general form of this specimen is that of *B. cognatus* and it has sixteen arms. The azygous side is normal and the injury is in the ray opposite the azygous area. The azygous area is not exactly like a typical area in *B. cognatus*, because it is wider, in the superior part, and the plates are somewhat differently arranged, but it is near enough to that species to classify it there, unless for another reason it belongs elsewhere. The ray opposite the azygous area is bent out of shape, the plates are displaced, and it bears three arms. The arm formula, as represented in the specimen, is 3+3+3+4+3. Suppose the ray were straightened and supported only by two arm openings directly in line with it, and that the ambulacral openings, which are above the interradial area, on the left, belonged to the ray on the left, the arm formula would be 3+4+2+4+3, which would represent, what we suppose would be, one of the normal varietal forms of *B. cognatus*. And it may be, after all, that the interior will show that to be the arrangement of the ambulacral canals. If so, it makes *B. cognatus* as variable as *B. variabilis*. We think *B. cognatus* will never be found with a normal ray having three arms opposite the azygous area. But we think the specimen under consideration is a *B. cognatus*, and that an injury produced the crooked radial series and displaced the ambulacral openings to the vault. If this view is correct, then the abnormal specimen represented by figures 24 and 25, for additional reasons, belongs to a nineteen or twenty-armed species.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of A. Albers.

BATOCRINUS ARGUTUS, Miller & Gurley.

[*Batocrinus argutus*, Miller & Gurley, 1896, Bull. No. 8, Ill. St. Mus. Nat. Hist., p. 9, pl. 1, fig. 8 and 9.]

The type of this species has twenty-one arms, two plates in each interradial area, the second one small, and six plates in the azygous area, 1+3+2. The five-armed ray is on the left of the azygous area as we see it looking at the illustration.

Mr. F. A. Sampson has a specimen from the same locality having a similar form and twenty-one arms. But the five-armed ray

is on the right of the azygous area, there is only one plate in each regular interradial area and five plates in the azygous area, 1+3+1. The question presented is whether or not these differences are of specific importance. A single additional small plate, in any one interradial area could hardly be claimed to be of specific importance; and, for the same reason, we think the additional small plate, in each area, is not of specific importance. We allow for greater variation, in the interradial area, within the limits of a species, than we do in the arm formula, in the calyx, and yet, there is an absence of definiteness, in a description, that reads "one or two regular interradials and five or six azygous plates." However, in this case, it is a small plate that is absent, in each area, and which does not noticeably change the form of the body.

Having disposed of these differences, the question still remains, whether or not the arrangement of the five-armed ray on the right or left side of the azygous area is of specific importance. We think it is not, and this leads us to some general remarks concerning the structure of crinoids. We think the azygous side of the calyx is the anterior side and the opposite side the posterior side. The early paleontologists took the contrary view, and much of the literature is written that way, and Billings, doubting the correctness of the old view, and probably believing as we do, proposed the use of the word azygous, as applied to one side, and we have followed his method of nomenclature, in order that our definitions might the more readily be compared with the work of others. Believing that the azygous side is the anterior side of the crinoid, we can see no reason why, in a twenty-one-armed species, it should be deemed material whether the five armed ray is on the right or left side of the front interradial space, and the examination of large quantities of material belonging to many species seems to us to indicate that it is not of specific importance. But it does seem material, whether a five-armed ray is on the anterior side, in one specimen, and on the posterior side in another; for here the variation is in essentially different parts of the body, and our observations, in all cases, even in *Batocrinus variabilis*, confirms this view.

We are aware that some pseudo-biologists call the vault the ventral side of a crinoid and the calyx the dorsal side; but the

vault was never ventral to the body of the animal, nor was the calyx dorsal to the body of the animal. The words ventral and dorsal cannot be applied to a crinoid, in this way, with any more reason than the roof of a house can be called the ventral side and the cellar the dorsal side. The crinoid stood upright, and all the organs were in that position, except the ovarian pores and ambulacral canals, from the base of the arm to the ring surrounding the top of what Meek called the "convoluted organ." One side was evidently anterior and the other posterior, and we have no doubt that the azygous side is the anterior side and the opposite one posterior. Looking at the crinoid in this view, the left side is the right side of an illustration. But in all cases, when we have used the words right side or left side, we have referred to the illustration and not to the disputed question as to which was the right side or the left side of the animal itself. It is no easy task to reform the crinoid literature and reduce it to a uniform, plain system, governed by a simple statement of the facts as they are known to exist, and we have not undertaken it.

Mr. A. Albers has a specimen of *B. argutus*, from Burlington, Iowa, that has the arms arranged just as they are in the type, and it has the same form and number of regular interradials, but it has seven axygous plates instead of six. The additional azygous plate is a small one in the third range on the left of the azygous area. The fact that this twenty one armed species occurs at Sedalia and at Burlington, is another evidence of the fixity of the species, and of the value of the radial series, within the calyx, in determining the limit of a species.

In describing *B. argutus*, we were made to say, that it is the first species bearing twenty-one arms, described from the Burlington Group; but we should have said, it is the second species, for *B. rotundus* was described many years ago and possesses twenty-one arms.

The study of animal life has led the most extensive observers and best thinkers to the conclusion that nature is continuous, and the more complete the knowledge of any particular family or genus, the less differentiated are the species, in the mind of the observer, because of the existence of intermediate forms. There are hard lines, however, that separate many species, in the fossil world, and these are found, evidently, among the crinoids. We

find hundreds of specimens, differing in size, but possessing absolutely the same characters, but do not find any near relative, and, in such case, we claim to have found a distinct species. The intermediate forms, if such existed, we do not find, and hence, are unable to ascertain from what direction the species came or where it drifted. The development, in a particular direction, may have been arrested by the extinction of the species, and, in such case, the last form would be stamped with unalterable characters. It is common, in the genus *Batocrinus*, to find specimens differing, only, in the number of plates, in one or more of the interradial areas. That is, the specimens will have the same general form and appearance, and the same arm formula, and the same structure, in the lower part of the regular interradial and azygous areas, but, in the superior part of one or more of the areas, there will be one or two more plates in one specimen than in another. In *B. argutus*, there would be three species, if the variations in the interradials above mentioned were of specific importance, and if we had more specimens we might have more of the same kind of variations. *B. glaber* would furnish eight or ten species, among the specimens, in our collections, if such variations constituted specific differences. And so we might almost indefinitely increase the species of *Batocrinus*, if such variations are of specific value. It is quite true, too, that numerous specimens have been collected belonging to some of the species of *Batocrinus*, that have shown no differences in the interradial plates. But that does not prove that other specimens will not show any differences. It is no evidence at all. On the contrary, it is consistent with what we know of animal life to suppose that other specimens will show variations, notwithstanding the apparent fixity in form and structure of any number of specimens that we might happen to collect in any particular species. The number that any one may happen to be fortunate enough to see, in any of these fossil species, is like a drop in the ocean when compared with the millions of specimens that must have existed.

BATOCRINUS REPERTUS, n. sp.

Plate IV, Fig. 28, azygous side. Fig. 29, opposite view; Fig. 30, summit.

Species below medium size. Calyx bowl-shaped, the projections of the radial series at the top give it a somewhat pentagonal outline, when seen from above; more than one-half wider than high. Plates convex. Radial ridges undefined. Surface finely granular. Column small and pierced by a small, cinquefoil canal.

Basals form a small hexagonal disc, with re-entering angles. The disc expands slightly upward and has a diameter about one-half greater than the diameter of the column, which is inserted in a rounded, radiately lined depression below. The lower and outward sides of the basals are rounded. First primary radials the largest plates in the body, a little wider than long, three hexagonal, two heptagonal. Second and third primary radials together smaller than the first. Second primary radials, quadrangular, twice as wide as long. Third primary radials a little larger than the second, one heptagonal, two hexagonal and two heptagonal, axillary, and, in the ray opposite the azygous area, which bears the heptagonal plate, support, on each upper sloping side, two secondary radials, which gives to this ray two arms. In the ray, on each side of the azygous area, the third primary radials, which are pentagonal, support, on each upper sloping side, two secondary radials, the last one, which adjoins the area, is axillary, and supports, on each upper side, a single, tertiary radial, which gives to each of these rays three arms. One of the lateral rays is constructed in the same way and bears three arms. In the left lateral ray, the second secondary radials are both axillary, and support, on each upper side, a tertiary radial, which gives to this ray four arms. There are, therefore, fifteen arms in this species. The arm formula is 3+3+2+1+3.

There are three plates in each regular interradial area, one followed by two smaller ones, in the second range, which do not connect with the vault. There are nine plates in the azygous area. The first one is in line with the first primary radials and about the same size. It is followed by three plates, in the second range, three plates, in the third range, and two plates in the fourth range, that connect with the plates of the vault.

Vault only moderately convex and covered with small, convex, polygonal plates, and bears a subcentral proboscis.

This species has little or no resemblance to *B. modulus* or *B. variabilis*, the other two species, bearing fifteen arms, described from the Burlington Group. In form, it more resembles *B. adamsensis*, a ten-armed species, or *B. imparilis*, a twelve armed species, or *B. longirostris*, an eighteen-armed species. A very beautiful series of bowl-shaped species might be arranged, bearing from ten to twenty arms.

Found in the Burlington Group, at Sedalia, Missouri, and now in the collection of F. A. Sampson.

BATOCRINUS SEDALIENSIS, n. sp.

Plate IV, Fig. 31, azygous side; Fig. 32, opposite view.

Species rather below medium size, biturbinate, vault having a capacity equal to or greater than the calyx. Calyx obconoidal, about twice as wide as high. Plates pyramidal.

Basals small, thin, and projecting slightly beyond the end of the column. First primary radials about one-half wider than long and sharply pyramidal, three hexagonal, two heptagonal. Second and third primary radials together very little larger than the first. Second primary radials quadrangular, about twice as wide as long. Third primary radials larger than the second, three hexagonal, two pentagonal, axillary, and supporting, on each upper sloping side, a single secondary radial, which is axillary, and supports, on each upper sloping side, a single tertiary radial, which gives to each ray four arms and four ambulacral openings to the vault. There are, therefore, twenty arms in this species. The arm formula is 4+4+4+4+4.

The azygous and regular interradial areas are cut off from the plates of the vault by the union of the tertiary radials above them. There are three plates in each regular interradial area, one followed by two smaller ones, in the second range. There are six plates in the azygous area. The first one is in line with the first primary radials and larger than either one of them. It is followed by three plates in the second range, one, in the third range and one in the fourth range.

The vault is broadly and highly convex and bears a small subcentral proboscis. It is covered with polygonal plates that are produced in short, sharp spines.

This species is probably most nearly related to *B. proboscidialis*, which was described by Hall as *Actinocrinus pro boscidialis*, and has generally been referred to *Actinocrinus*, by later authors, though it is a true *Batocrinus*. If, however, the character of the vault and proboscis is of specific importance, they may be readily distinguished. In *B. proboscidialis* the vault is terete conical, and is gradually produced into a large and long proboscis. In this species the vault is broadly convex and bears a small subcentral proboscis. The species are farther distinguished by the following characters. In *B. proboscidialis*, the surface of the plates of the calyx is marked by short angular ridges, which terminate in a bi-nodose, transverse ridge, on the first radials, and in a strong angular node above; in this species, there are no angular ridges, or bi-nodose, transverse ridges, but the plates are all pyramidal and terminate in angular points. In *B. proboscidialis* there are four plates in each regular interradial area disposed in three ranges; in this species there are three plates, disposed in two ranges. The azygous areas are also different. But notwithstanding all these differences, both species have the same arm formula and the same number of secondary and tertiary plates, in the calyx, and, therefore, must be nearly related.

Found by R. A. Blair, in the Burlington Group, at Sedalia, and now in the collection of S. A. Miller.

BATOCRINUS SUBEQUATUS, n. sp.

Plate IV, Fig. 33, azygous side; Fig. 34, opposite view; Fig 35, summit.

Species small, below medium size, biturbinate, calyx and vault subequal in capacity. Calyx bowl-shaped, slightly flattened, in the superior part of the interradial areas, about one-third wider than high. Radial ridges undefined. Plates convex. Surface granular.

Basals form an hexagonal, slightly expanding, disc, truncated the entire width below, by the column, which is supported in a radiately lined, hemispherical depression. First primary radials as large as the second and third together, wider than long, three hexagonal, two heptagonal. Second primary radials quadrangular,

twice as wide as long. Third primary radials a little larger than the second, pentagonal, axillary, and in each ray adjoining the azygous area, bear upon the distal side, two secondary radials, and upon the proximal side, an axillary radial, which bears upon each sloping side a single tertiary radial, which gives to each of these rays three arms. One of the lateral rays is constructed in the same way and bears three arms. In the other lateral ray and in the ray opposite the azygous area, the third primary radials support, upon each upper sloping side, two secondary radials, which gives to each of these rays two arms. There are, therefore, thirteen arms in this species. The arm formula is 3+2+2+3+3.

The azygous and regular interradial areas are all cut off from the vault by the union of the radial plates above them. There is one regular interradial in each area. There are five plates in the azygous area. The first plate is in line with the first primary radials and longer than either of them. It is followed by three plates in the second range, and a smaller intercalated plate to the right of the upper part of the middle plate.

The vault is obconoidal, covered with polygonal plates and bears a central proboscis.

This species has little resemblance to either of the other three thirteen-armed species that have been described from the Burlington Group, and need not be compared with any of them. It is quite a peculiar species, and at present we do not know where its nearest relative may be found.

Found by F. A. Sampson, in the Burlington Group, at Sedalia, Missouri, and now in his collection.

REMARKS ON THE FAMILY ACTINOCRINIDÆ.

This family prevails above all other crinoids, in the Subcarboniferous rocks of North America. It first appeared, as now understood, and of course, we can only speak within the limits of the present state of learning, in the Niagara Group of the Upper Silurian, and ended, within the Subcarboniferous. The Upper Silurian genera are *Cylicocrinus* and *Saccocrinus*, neither of which are known to occur in the Devonian or Subcarboniferous, though one species, described by Meek and Worthen, as *Actinocrinus amplus* from the Burlington Group, has been referred to Sacco-

crinus. The species is nearer *Actinocrinus* than *Saccocrinus* and is best retained, in the genus, to which it was first referred. It cannot be considered as a connecting link, until a way is found, to pass through the Devonian System and Chouteau Group. Two species of *Cylicocrinus* have been described and the specimens are small. Fifteen species of *Saccocrinus* have been described, varying greatly in size, but *S. urniformis* and *S. marconanus* have the largest bodies belonging to any species, in the *Actinocrinidæ*. There are ten ambulacral openings to the valt in *Cylicocrinus*, but whether or not the arms bifurcate after becoming free is unknown. In *Saccocrinus* there are either ten or twenty ambulacral openings to the vault, and the arms, in *Saccocrinus speciosus* are known to bifurcate twice after becoming free, giving to that species forty arms, and, in other cases, where there are twenty ambulacral openings, the arms are known to bifurcate once so as to give the species, at least, forty arms.

The Devonian genera are *Gennæocrinus*, *Megistocrinus* and the species described by Hall from the Hamilton Group as *Actinocrinus præcursor*, which may be a *Batocrinus*. There are seven speceies of *Gennaescrinus*, and, in those species, in which the arms have been described, there are sixteen, twenty, thirty and forty arms. None of the species have large bodies. There have been twenty-five species of *Megistocrinus* described. They are generally large, ranking next to *Saccocrinus*, though quite variable, in size; but there is great uniformity, in the general shape of the different species. This genus occurs in different Groups of the Devonian System and in the Kinderhook and Burlington Groups of the Subcarboniferous. It is the only genus, in this family, that is known to pass from one geological system to another. The arms of the various species are, generally, unknown, some of them, probably, bifurcate and others do not. The ambulacral openings to the vault, in some of the species, cannot be determined from the imperfect descriptions that have been written, and there is doubt about others. Among the Devonian species, the number of ambulacral openings to the vault, that are definitely known, are ten, fourteen, sixteen, seventeen, twenty, twenty-seven and thirty, and in the Kinderhook and Burlington Groups ten and twenty. The prevailing Devonian species have sixteen ambulacral openings, a number thus far unknown, in the Subcarboniferous.

In the Subcarboniferous system we find *Actinocrinus*, *Agaricocrinus*, *Alloprosallocrinus*, *Amphoracrinus*, *Batocrinus*, *Blairocrinus*, *Dorycrinus*, (*Megistocrinus* above mentioned) *Physetocrinus*, *Sampsonocrinus*, *Shumardocrinus*, *Steganocrinus*, and *Strotocrinus*. In this disposition of the genera we regard *Erelmocrinus* as a synonym for *Batocrinus* and *Teleiocrinus* as a synonym for *Strotocrinus*.

Blairocrinus, *Sampsonocrinus* and *Shumardocrinus* are confined to the Chouteau limestone. There are four species of *Blairocrinus*, each of which bears twenty arms, one species of *Sampsonocrinus* that has nineteen ambulacral openings to the vault, and one species of *Shumardocrinus* that has five ambulacral openings to the vault, and the free arms are not known in either species. There are five species of *Actinocrinus* described from the Chouteau limestone and Kinderhook Group, having twenty, twenty-two, and thirty ambulacral openings to the vault. Four species of *Agaricocrinus*, having nine and ten ambulacral openings. Four species of *Amphoracrinus* having six and ten ambulacral openings and one with twenty arms. Three species of *Batocrinus*, having twenty ambulacral openings. And three species of *Dorycrinus* having respectively twelve, fourteen and eighteen arms.

Physetocrinus, *Steganocrinus* and *Strotocrinus* are confined to the Burlington Group. There are nine species of *Physetocrinus*, having twenty, thirty-four, forty and fifty arms. There are four species of *Steganocrinus*, having five large, ambulacral openings to the vault and numerous armlets of a peculiar character. And there are twenty species of *Strotocrinus*, having twenty, twenty-six, thirty, forty, fifty, sixty, seventy, eighty and one hundred arms There are fifty-three species of *Actinocrinus*, described from the Burlington Group, having ten, twenty, twenty-one, twenty-two, twenty-four, twenty-nine, thirty, thirty-six and forty arms; the greater number have twenty and thirty arms. Eighteen species of *Agaricocrinus*, having ten and twelve arms. Six species of *Amphoracrinus*, having ten, twenty and twenty-two arms. One hundred and eleven species of *Batocrinus*, having eight, ten, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, twenty, twenty-one, twenty-two, twenty-three, twenty-four, twenty-six and twenty-seven arms, the prevailing species having eighteen, twenty and twenty-two ambulacral openings to the

vault. And twenty-three species of *Dorycrinus*, having ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, nineteen and twenty arms, the prevailing species having twelve and sixteen arms.

There is no genus confined to the Keokuk Group, and all that are found within it passed up from the Burlington Group below, except *Alloprosallocrinus*. There are twelve species of *Actinocrinus*, having twenty-five, twenty-nine, thirty, thirty-eight and forty arms or more. A peculiarity, in some of the species, as in *Actinocrinus gibsoni*, is the bifurcation of the arms after they become free, as they do, in some species of *Saccocrinus*. The prevailing species have thirty ambulacral openings to the vault. There are seventy-two species of *Balocrinus*, having twelve, fourteen, fifteen, sixteen, seventeen, eighteen, twenty, twenty-one, twenty-two, twenty-four, twenty five, twenty-six, twenty-eight, twenty-nine, thirty, thirty-two, thirty-six and forty arms. The prevailing species have sixteen, seventeen, eighteen and twenty arms. There are eighteen species of *Agaricocrinus*, having ten, twelve, thirteen, fourteen, sixteen and eighteen arms. The prevailing species have ten and twelve arms. There is only a single species of *Alloprosallocrinus*, and it has eleven arms. There is only a single species of *Amphoracrinus*. It was originally referred to the Waverly Group and described under the name of *Actinocrinus viminalis*. It has only ten ambulacral openings to the vault, but the arms bifurcate so that there are forty arms in the superior part. The association of crinoids at Richfield, in Summit county, Ohio, very clearly indicates that the rocks are above the Waverly Group and belong to the Keokuk. There are seven species of *Dorycrinus*, having sixteen, seventeen and twenty arms. The prevailing species have twenty arms.

Authors have not clearly distinguished between the Warsaw and St. Louis Groups, though most of the species are referred to the Warsaw Group, and there are so few species we will consider the two Groups together. First, it will be noticed, that no *Actinocrinus* are found above the Keokuk Group. Sixteen species of *Balocrinus* have been described, having seventeen, eighteen, twenty and forty arms. The principal species have eighteen and twenty arms. One *Dorycrinus* has been described having ten arms and three species of *Alloprosallocrinus*. And here the family of the *Actinocrinidæ* became extinct, unless *Balocrinus copiosus* is a representative of the Kaskaskia Group. It was

credited to the Kaskaskia Group, when it was described, but we are now of the opinion that it came from rocks of the age of the Warsaw or St. Louis Groups, and that, so far as our knowledge now extends, the family of the *Actinocrinidæ*, during the age of the St. Louis Group, ceased to exist.

We have mentioned eighteen genera belonging to the *Actinocrinidæ*, which are more than belong to any other family of crinoids; and we have enumerated four hundred and fifty-two species belonging to it, which are more than belong to any other family. We have called attention to the geological distribution of the genera and species and also to some of the distinguishing characteristics. What conclusions, if any, are to be drawn from the facts thus set forth?

It appears that *Saccocrinus*, the first genus to appear on the stage, grew to the largest size, developed fifteen species, bearing from ten to twenty ambulacral openings to the vault, and that the arms bifurcate, in *Saccocrinus speciosus*, twice after becoming free. (See Pal. N. Y., vol. 2, Pl. XLVI, fig. 1). The same kind of arms and the same method of bifurcation may be seen in *Amphoracrinus viminalis* from the Keokuk Group. (See North American Geology and Palæontology, p. 222; and Ohio Pal., vol. 2, Pl. II, figs. 12 and 13). And the same kind of arms and the same method of bifurcation may be seen in *Actinocrinus gibsoni*, from the Keokuk Group. (See Bull. No. 3, Ill. St. Mus. Nat. Hist., Pl. II, fig. 1). And the same may be seen in other genera and species, in large collections, which have not been illustrated. It follows, therefore, that bifurcating arms composed of a double series of interlocking plates is not a feature of generic importance. This might be proved again by the single and double arms, in the same specimen, in different species of *Batocrinus*, illustrated on Pl. I, in Bull. No. 7, Ill. St. Mus. Nat. Hist. The number of ambulacral openings to the vault is not of generic importance, not only as shown by *Saccocrinus*, but by *Megistocrinus*, *Batocrinus* and other genera that include numerous species.

The largest forms and very small ones appeared abruptly in *Saccocrinus* and *Cylicocrinus*, in the Niagara Group, as perfect, in all their parts, so far as we know or have reason to believe, as any that existed in later periods; and they became extinct as abruptly as they appeared, in the same geological age. There are no intermediate forms—from these genera to *Gennæocrinus* and *Me-*

gistocrinus—that appeared as abrubtly in the Upper Helderberg and Hamilton Groups. There is no process of development or evolution of which we have or can have any conception that will link any of these genera together by lines of direct descent. *Megistocrinus* survived until the age of the Burlington Group, and then disappeared as abruptly as it came into existence; and during all that time specific variations were taking place, but there are no indications of another genus branching from it or arising out of it. *Blairocrinus*, *Sampsonocrinus* and *Shumardocrinus* appeared without progenitors and disappeared without descendants in a single geological age. Suppose that from *Gennæocrinus* arose *Actinocrinus* and *Amphoracrinus*, and from the form called *Actinocrinus præcursor* arose *Batocrinus*, we still have the abrupt appearance of *Agaricocrinus* and *Dorycrinus* in the Chouteau Group, without progenitors, and they became extinct without having developed other genera. We might suppose that from *Actinocrinus* and *Amphoracrinus* arose *Physetocrinus*, *Steganocrinus* and *Strotocrinus*, and from *Batocrinus* arose *Alloprosallocrinus*, but the supposition is the merest guess of a possibility, without any facts to support it. But, if true, they disappeared from the stage of living existence abruptly, immediately following the growth of the largest species and most fruitful and prolific forms, in the very middle of the subcarboniferous age.

No one can contemplate the creation of something out of nothing, or what is called special creation; hence, the theory of evolution and development of animal life. Pseudosystematists and pseudobiologists, after having examined a few fossils, draw their conclusions concerning the embryological, larval, mature and declining stages of development of genera and species; without presenting a fact or principle to support the conclusions, they rest on technical names and barren assertions. Their ideas of evolution and of the vast and incomprehensible stages of life represented in palæozoic time, are so contracted that they would have you believe they have discovered the laws and limitations, so that the ordinary schoolboy can understand and apply them to all the fossil forms that have been or may be found. In their narrow minds they have contemplated all the resources of nature during the immeasurable ages of the past. We have looked at more than fifty thousand specimens of fossil crinoids, and have carefully examined several thousands belonging to the family here under con-

sideration, and we are free to say we have not found any embryological, larval, mature or declining stages of development. Nor has our study caused us to believe any one has or ever will find such stages represented in the tests of the fossils under consideration.

If evolution has been the course of animal life, it must have been commensurate with the lapse of geological ages, not only as represented by the deposits, but including the time indicated by the unconformability and breaks that form the dividing lines between groups of rocks. And the interruption of the course found at these dividing lines is far greater than the development or evolution found within the deposits themselves. We are not surprised, therefore, to find *Saccocrinus* and *Cylicocrinus* without progenitors or descendants. They may have emigrated or been driven by ocean currents from the homes of their ancestors to where we find the tests; and in like manner they may have been carried away to foreign climes not suited to their habits of life, where they became extinct without leaving any degenerate descendants. If such were the case, we will never see any but such natural forms as we have found. Of course the smaller specimens may have died younger than the larger ones did, but there is nothing embryological or larval in their state of development. The largest species are found, in the Niagara Group, at Chicago, Illinois, the smallest species in Indiana, and the medium-sized species in New York; but all of them occur in the middle or upper part of the Group, and they were not, therefore, ushered in at the beginning of that geological age.

What we have said of those two genera is also applicable to *Megistocrinus*, that appeared at the outset, in the middle Devonian rocks of Indiana and Michigan, with numerous species, varying in size, from the smallest to the largest and with the greatest varieties of form and structure, and then disappeared from the last half of the Devonian age, and crossed the vast lapse of time indicated by the break, between the Devonian and Subcarboniferous rocks, and reappeared, in the Chouteau Group, represented by other and different species and again reappeared by other and different species in the Burlington Group, and then disappeared forever. But there are no embryological or larval forms, nor anything in the test of the last living species to indicate a declining structure or degenerate descendant from the Devonian series. And

what we said of *Saccocrinus, Cylicocrinus* and *Megistocrinus* may be said with equal force of *Blairocrinus, Sampsonocrinus, Shumardocrinus, Agaricocrinus, Batocrinus,* and *Dorycrinus.* If this manner of reasoning is at all admissible, with what show can we say that from *Gennacocrinus* arose *Actinocrinus* and *Amphoracrinus?* Is it not the merest guess upon the most remote possibity?

The theory of evolution does not mean that animal life was continually improving in any or all of the channels of its existence, nor that it was declining when not improving. Neither did it pass through cycles from the embryo to senility, in genera, families, orders or classes. On the contrary, if of any value as a theory, the evolution must conform to what we find in nature, and that is almost ceaseless change, without necessarily involving advancement or decline; but conformability, with environment and surroundings. And we do not find what we call advancement or a higher degree of development, neither do we find a decline or degradation, in the family of the *Actinocrinidæ*, from its appearance in the Upper Silurian, to its disappearance, in the St. Louis Group. Nor do we find any development to a higher or decline to a lower stage of existence, in any of the genera or species, during all that period. The species are the most abundant in the Burlington Group, and the variations within specific limits, are more numerous there than elsewhere. And, having fixed upon certain characters, which we call specific, we observe, where species are most abundant and fruitful, the greatest tendency to break over these lines, so as to leave it doubtful, sometimes, whether a particular form should be regarded as a variety of a described species or as a distinct species. This occurs among the *Megistocrinus*, in the Hamilton Group, and among the *Batocrinus*, in the Burlington and Keokuk Groups; but we do not see in it any progress toward senility of the species or the reverse. In fact, we do not know whether ornamentation of the test indicates strength or weakness. We do not know whether *Megistocrinus ornatus* with its delicate sculpturing is in a higher or lower stage of development than *M. spinosulus*, with its canopy of spines; nor whether *Batocrinus nodulosus*, with its proboscis, ornamentation and tumid plates is in a higher or lower stage of development than *B. oblatus*, with plane, smooth plates and no proboscis. We do not know whether *B. oblatus* with its twenty-two arms

is in a higher or lower stage of development than its congener *B. rotundus*, with twenty one arms. In short. we do not know what, if any, specific characters, in any of the genera, indicate progress or decline, though we may notice that *Balocrinus*, having tumid plates, are more abundant and have a greater geological range than those with smooth plates, and that twenty-armed species are more common than thirteen armed spicies. We must not drift away from our mooring and forget that we have seen only a small part f what the rocks have preserved, and that it is possible, for others, in future, to see a thousand times as many specimens as we have, with corresponding advantages for examining the structure, and drawing conclusions as to the evidences of development. We attempt to speak only from the present state of science and our own investigations.

FAMILY POTERIOCRINIDÆ.

BARYCRINUS SAMPSONI, n. sp.

Plate IV, Fig. 1, basal view; Fig. 2, azygous side, Fig. 3, opposite view.

Species large, robust. Calyx about one and a half times as wide as high. Plates very thick and highly convex. Angles of sutures without pits. Column rather small, as shown by the cicatrix. Surface, apparently smooth, probably granular.

Basals small and form a low, pentagonal cup or disc, with reentering angles. It is pierced by a small columnar canal, surrounded by a cicatrix, for the attachment of the column, having a diameter a little more than one-third the greatest diameter of the disc. The cicatrix bears five rounded, concave, radiately lined depressions for the firmer adherence of the column. The plates are quadrangular, without counting the side that abuts upon the canal, and the adjoining sutures are beveled, so that the form of the convexity of the plates is somewhat pyramidal. Subradials about four times as large as the basals, as long as wide, highly tumid, three hexagonal, two heptagonal, by reason of abutting the small, intercalated, azygous plate, and the other octagonal, by reason of abutting the two azygous plates. First radials about twice as large as subradials, one-fourth wider than high, remarkably thick, and broadly and deeply excavated for the attachment of the second

radials. The facet has an inclination of nearly forty-five degrees. The first radials are truncated, at the superior lateral angles, by single interradial plates. A small, triangular, elongated, azygous plate is intercalated between the subradials and below the first radial, on the right of the azygous area. Another quadrangular azygous plate, longer than wide, broadly truncates a subradial and separates two first radials. These two azygous plates do not come together.

This species is distinguished by the rapid increase in size from the basals to the first radials. By the great thickness and convexity of the plates, without angular pits. Inclined facet for the second radials, and by the azygous plates.

Found by F. A. Sampson, in whose honor we have proposed the specific name, in the Burlington Group, at Sedalia, Missouri, and now in his collection.

POTERIOCRINUS BOZEMANENSIS, n. sp.

Plate V, Fig. 11, side view, natural size, showing part of the proboscis; Fig. 10, same magnified two diameters. The specimen is on a slab

Species very small. Calyx obconoidal, one-third wider than high. Plates rounded, with the slightest convexity, but showing the sutures. Surface apparently smooth. Column small.

Basals small and extended but little beyond the column. Subradials two or three times as large as the basals and nearly as long as wide. First radials very little if any larger than the subradials, a little wider than long, and truncated the entire width above for the first arm plates, from which they are separated by a very slightly gaping suture. The arms do not bifurcate, and hence there are only five arms in this species. The first plate is very long and round externally, but the plates rapidly shorten and bear alternate pinnules.

The azygous area is not exposed in our specimen, but from the form of the calyx and the piece of the proboscis that is exposed there can be little or no doubt of the generic relations. The part of the proboscis which is exposed and illustrated is round and composed of four series of plates.

This is a peculiar species, and so different from all others that no comparison with any of them is necessary.

Found by Earl Douglass in the subcarboniferous rocks of Bridger mountains, near Bozeman, Montana, and now in the collection of S. A. Miller.

POTERIOCRINUS DOUGLASSI, n. sp.

Plate V, Fig. 16, side view, with the azygous area on the right; Fig. 17, same magnified two diameters. The specimen is on a slab.

Species small. Calyx short, obconoidal, one third wider than high. Plates convex; sutures distinct. Surface granular. Column rather large, round, every alternate plate projecting.

Basals form a low cup that is truncated for the column and expanded above. Subradials larger than the basals and nearly as long as wide. First radials as much larger than the subradials as the subradials are larger than the basals, wider than long, pentagonal, truncated the entire width above, and separated from the second radials or brachials by a gaping suture. A single, elongated, brachial or second radial, rounded and contracted in the middle, and axillary, supports upon its superior sloping sides, in each radial series, the free arms. The arms do not again bifurcate, and hence there are ten arms in this species. The arms are composed of very long, slightly constricted plates, that alternately project on each side, for the support of coarse, long-jointed pinnules.

The first azygous plate cannot be seen in our specimen. The second plate is large, truncates a subradial and extends as high as the middle of the first brachial. The plate succeeding it is much smaller; only part of the alternate plate on the right can be seen, but enough is exposed to show the usual alternate arrangement that characterizes this genus.

This species is distinguished by the form of the calyx, single brachials and structure of the arms. While it is not conspicuously marked by any peculiar feature, yet we do not know of any species with which it might be confounded.

Found by Earl Douglass, on the Bridger mountains, at Bozeman, Montana, and the name is in honor of the collector. The specimen illustrated is in the collection of S. A. Miller.

FAMILY RHODOCRINIDÆ.

GONIASTEROIDOCRINUS FABERI, n. sp.

Plate V, Fig. 2, basal view; Fig. 3, side view.

Species large. Calyx subcylindrical to near the summit where it curves outward. No radial ridges. Basal plates depressed. The other plates tumid, nodose or spinous. Our specimen is a cavity in a rock, preserving all the external features of the calyx, except the sutures between the basal plates, and by taking an impression from it the artist has been able to furnish a basal and side view.

The basal plates form a regular pentagon one-half wider than the diameter of the column. The column is round. Subradials large, almost regularly hexagonal, and each one bears a long, sharp, conical spine, that is directed downward, at an angle of about forty-five degrees. The calyx will rest upon the points of these spines. First radials a little smaller than the subradials, wider than long, heptagonal, and each one bears a long, sharp, conical spine that is directed horizontally. Second radials about one-fifth as large as the first, convex, quadrangular and longer than wide. Third radials about twice as large as the second, tumid, octagonal, and support on each superior lateral side two secondary radials. The superior face is truncated by an intersecondary plate that is followed by two plates in the second range. The calyx curves out rapidly, from the third primary radials, and the secondary radials spread, so that at the summit of the second secondary radials, they are directed laterally at an angle of about forty-five degrees. Beyond this point our specimen is not preserved. These plates are subnodose.

There are ten plates shown in an interradial area in our specimen, and we suppose that to be the limit. The first plate is almost in line with the first primary radials and about two-thirds as large, hexagonal, and bears a long, sharp, conical spine that is directed horizontally. It is followed by three smaller, subequal plates in the second range, each one of which bears a large central node; and these are followed by three still smaller plates in the third range, each one of which bears a central node. Above these there are three plates shown in our specimen, each one of which bears a small central node.

On the slab, which is chert, containing our specimen there are the casts of what we suppose to be part of the pseudo ambulacral appendages or ovarian extensions, but they are not connected with the calyx, and for that reason are not illustrated. If they represent these appendages, they are much larger than any belonging to any of the described species of *Goniasteroidocrinus*.

Found in Subcarboniferus rocks, probably of the age of the Keokuk Group, near Joplin, Missouri, and now in the collection of Charles L. Faber.

Family CYATHOCRINIDÆ.

CYATHOCRINUS FABERI, n. sp.

Plate V, Fig. 12, basal view; Fig. 13, azygous side; Fig. 14, opposite view; Fig. 15, radial plate magnified two diameters.

Specimens medium size. Calyx about twice as wide as high, somewhat obconoidal, most expanded on the azygous side. Sutures distinct. Surface pustulous, the pustules sometimes uniting so as to form lines. Column round, medium size.

Basals small and form a low cup, with a shallow, concave depression for the attachment of the column. Subradials nearly as long as wide, the one on the azygous side being the largest. First radials of unequal size and from one-half wider than long to more than twice as wide as long, and truncated the entire width above for the second radials. The facets are inclined, indicating a gaping suture, and they are only slightly notched for the ambulacral canals. The azygous plate truncates a subradial and extends one-third of its length above the first radials.

This species is distinguished by its form and pustulous surface from all other illustrated species. There have been several species, in this genus, described without illustrations, and we have compared this species with the definitions, some of which are very unsatisfactory, but none of them seem to be like this one.

Found in the Burlington Group, at Burlington, Iowa, and now in the collection of Charles L. Faber, in whose honor we have proposed the specific name.

Family PLATYCRINIDÆ.

PLATYCRINUS DOUGLASSI, n. sp.

Plate V, Fig. 18, side view; Fig. 19, same magnified two diameters. The specimen is compressed so as to appear wider than it really is.

Species medium or below medium size and belonging to the round, bowl-shaped forms. Calyx round, bowl-shaped, truncated below, and, when not compressed, about as high as wide. Sutures are not beveled. There is a constriction just above the base so as to form a basal rim. The surface is furrowed transversely across the sutures between the first radials and longitudinally from the lower part of the facet for the second radials across the basal plate, but increasing in number, so as to cover the basal plates to the constriction above the basal rim. These furrows do not cross each other. The column is small and elliptical.

Basals form a low cup rather more than one-third the height of the calyx. First radials longer than wide and increasing in width very slowly in their upward extension, so that the calyx increases in width very little above the basals. Articulating facets for the second radials very slightly excavated, about one third the width of the plates. Second radials very short or transversely almost linear. Third radials short, axillary, and bear, upon each upper sloping side, the free arms. There are, therefore, ten arms in this species. The arms are long, slender, composed of projecting, cuneiform plates, bearing pinnules alternately. The pinnules are long and very dense. Our specimen is on a slab and there are fragments of the arms not illustrated, which show the unusual density of the pinnules.

The superior face of the first radials is transverse, without showing any evidence of interradials. Vault unknown.

This is a peculiar species, distinguished by its form and surface ornamentation from all others.

It was found by Earl Douglass, in whose honor we have proposed the specific name, on Bridger Mountains, near Bozeman, Montana, and now in the collection of S. A. Miller. The rocks from which it was collected are subcarboniferous.

FAMILY GLYPTASTERIDÆ.

GLYPTASTER MILLIGANÆ, n. sp.

Plate V, Fig. 7, azygous side of a small specimen; Fig. 8, side view of a larger specimen; Fig. 9, summit view of same.

Species variable in size. Calyx obpyramidal, truncated below only the size of the column. Plates highly convex. Radial ridges imperfectly defined. Higher than wide. Interradial areas flattened below and depressed between the arms. Surface smooth or finely granular. Column pentagonal. Columnar canal small and slightly cinquefoil.

Basals form a small pentagonal disc, with the angles directed toward the center of the subradials. Subradials large, longer than wide, having an angular ridge directed toward the center of each adjoining first radial and one toward an angle of the basal disc. A transverse section is pentagonal, with the angles at the center of the subradials, and re-entering angles at the sutures, as in the basal disc below; but from the center of the first radials upward, a transverse section is pentagonal, with the center of the radials in the angles. First radials rather larger than the subradials and a little wider than long. The one on the left of the azygous area hexagonal, the others heptagonal. Second radials much smaller and hexagonal. Third radials smaller than the second, axillary and support the free arms.

The first regular interradials are large, rest between the superior sloping sides of the first primary radials, and are followed by two much smaller plates in the second range, which unite with smaller plates that graduate to those of the vault, without any distinct line of separation. One can hardly say whether or not the third range should be classed with the plates of the vault. The first azygous plate truncates a subradial, and is followed by three plates in the second range, that unite with plates which should, probably, be classed with those of the vault.

The vault is depressed, convex toward the center and sunken toward the interradial areas. It is covered with numerous convex, polygonal plates, and bears a subcentral azygous orifice. There

is a slight swelling, commencing at the margin, in the azygous area and extending beyond the azygous orifice, that is covered with very small plates.

This is a marked and peculiar species, that cannot be mistaken for any hitherto described.

Found by Mrs. J. M. Milligan, of Jacksonville, Illinois, in whose honor we have proposed the specific name, in the Niagara Group, of Decatur county, Tennessee, and now in her collection.

FAMILY EUCALYPTOCRINIDÆ.

EUCALYPTOCRINUS MILLIGANÆ, n. sp.

Plate V. Fig. 4, basal view; Fig. 5, side view showing the constriction of the calyx; Fig. 6, side view of another specimen showing the sutures separating the interradials from the summit plates and constriction of the latter above the arms, the azygous orifice being at the top.

Species medium size. Calyx subturbinate, broadly constricted, in the middle part, and truncated at the base, Surface smooth or granular, our specimens being silicified the granules, if they ever existed, are destroyed. Column small and round.

Basals within the calyx and with the inferior part of the first radials form a pentagonal, funnel-shaped cavity for the reception of and attachment of the column. First radials wider than long, abruptly curved into the basal concavity, and upward, on the outside, so as to form a sharp, pentagonal rim at the base of the calyx. Second radials quadrangular, less than one-half wider than long. Third radials somewhat larger than the second, heptagonal, and support on each upper lateral side, two secondary radials, the last being axillary and supporting, upon its nearly transverse upper face, two arms. Above three or four transverse plates, the arms are composed of a double series of interlocking plates, as in other species. The outline of each arm, however, is more fusiform than usual.

The superior point of each third primary radial is truncated by a pair of elongated interbrachials as in the regular interbrachial areas, and these are followed by a long plate that is di-

vided internally, and extends to the top of the arms where it unites with a summit plate. The first regular interradial is of moderate size, ten sided, and followed by two elongated plates in the second range, and those by a long plate that is divided internally and extends to the top of the arms where it unites on either side with a summit plate. The arms when closed are compact, within furrows formed by the internal union of the long interbrachial plates. There are five plates at the summit that form a vault, which is constricted above the tops of the arms, and bears a central azygous orifice. This structure of the summit may be of generic importance, and, if so, this species would belong to *Hypanthocrinus*. We doubt the propriety, however, of founding any genus of crinoids, on the structure of the vault or proboscis, and, therefore, refer this species to Eucalyptocrinus.

This species is distinguished by the pentagonal, funnel-shaped, columnar cavity, broadly constricted calyx, fusiform arms, constricted vault and elevation of the azygous orifice.

Found by Mrs. J. M. Milligan, in whose honor we have proposed the specific name, in the Niagara Group, in Decatur county, Tennessee, and now in her collection, in Jacksonville, Illinois.

ORDER BLASTOIDEA.

Family CODASTERIDÆ.

CODASTER JESSIEÆ, n. sp.

Plate V, Fig. 20, basal view; Fig. 21, side view; Fig. 22, summit.

Calyx about one-fifth wider than high. Summit only moderately convex. Transverse section of the basals subtriangular, with concave sides. Transverse section above the basals subpentagonal. Surface without ornamentation.

Basals occupy nearly half the height of the calyx. They are longitudinal, depressed at the sutures and rounded in the middle part of each plate. The point for the attachment of the column is exceedingly small. The two larger plates are of equal size and pentagonal, the smaller one is tetragonal. Radials equal, wider than long and the mesial gibbosity gives the pentagonal outline to the summit. Part of the summit is destroyed in our specimen

and hence only part of it can be described. The pseudoambulacra are very narrow and there are only five hydrospire slits in an area.

This species is distinguished by its general form and smooth surface. The depressed sutures between the basals is a distinguishing feature, and so are the five hydrospire slits in an area.

Found by Miss Jessie Blair, in the Choteau limestone, at Sedalia, Missouri, and now in the collection of S. A. Miller. The specific name is given as a compliment to the finder.

CLASS CRUSTACEA.

SUB-CLASS XIPHOSURA.

ORDER EURYPTERIDA.

Family EURYPTERIDÆ

EURYPTERUS KOKOMOENSIS, n. sp.

Plate V, Fig. 1. the lower or ventral side of a nearly complete specimen.

This species seems to be about the size of *Eurypterus remipes*, but differing somewhat in the relative proportions of the body. The carapace is roundish or somewhat quadrangular with the anterior corners rounded and about seven-eighths as long as wide. The abdomen gradually widens from the carapace for three or four articulations and then contracts gradually to the last segment, or it may be said to be somewhat evenly rounded laterally. The posterior projections or angles of the segments are only partially preserved in our specimen, until the last segment is reached, and here they appear much larger than is usual, in this genus. There are twelve segments. Telson tapers slowly to near the end when it rapidly tapers to the point. The length of the telson is about two-ninths of the entire length of the animal.

There are only two pair of the palpi preserved, in our specimen, and they appear, as shown in the illustration. The limestone rock is disposed in thin layers and others may have been broken away without leaving a trace of their former existence. The pair of swimming feet are unusually large, but the specimen preserves little more than a bare outline of them. The mouth too is indistinct but the outline of the small post oral plate is preserved.

This species is distinguished from all others by the greater length of the carapace in proportion to its diameter and by the shorter telson. These characters are obvious. Its general form will readily distinguish it also.

Of course, if it never had but two pair of palpi, this would be a very marked and important distinction; but the parts preserved are so much like *Eurypterus*, that we suppose there were four pair and two have not been preserved.

Found in the Waterline Group, at Kokomo, Indiana, and now in the collection of Wm. F. E. Gurley.

PLATE I.

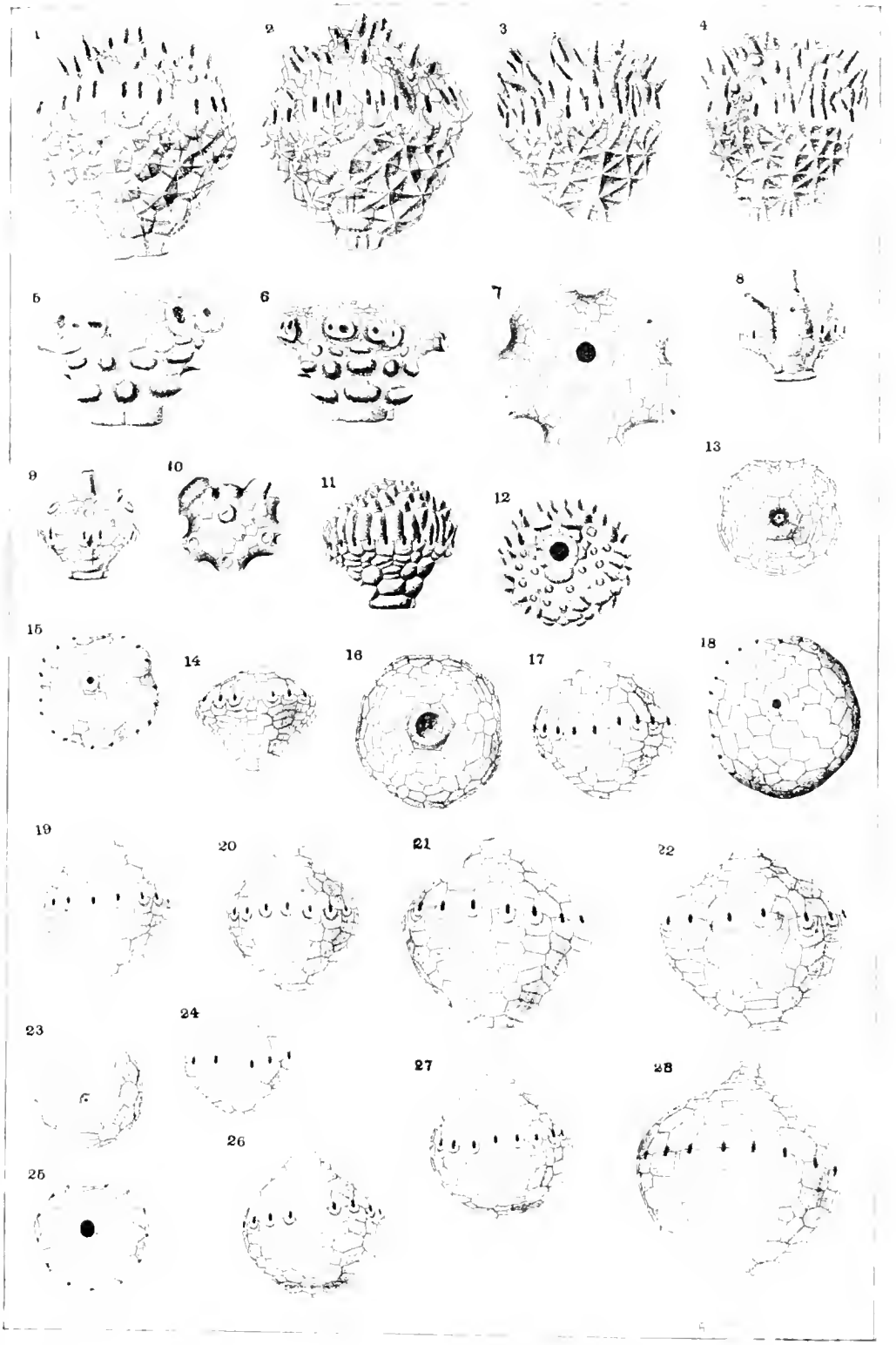
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PLATE II.

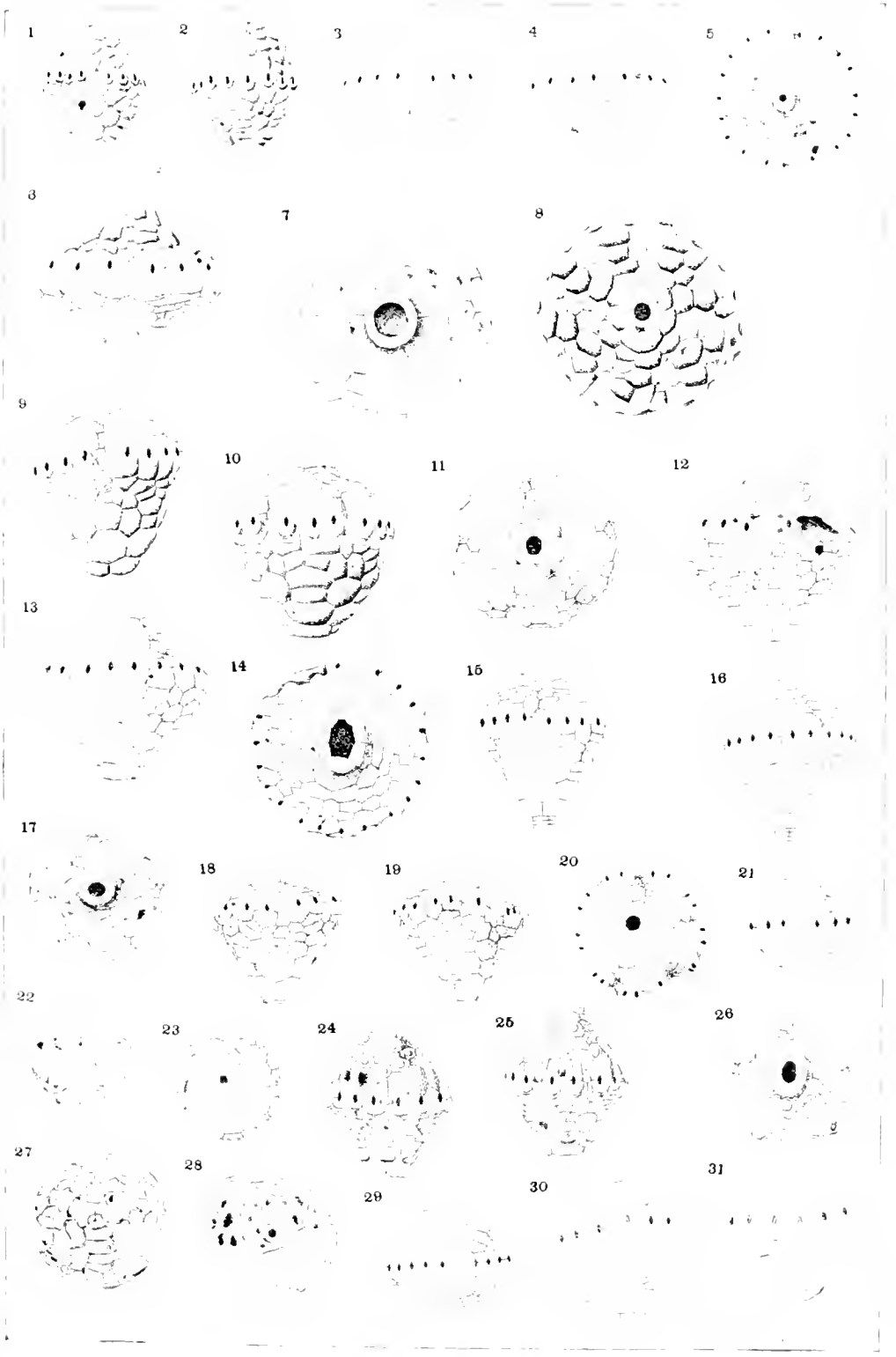
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PLATE III.

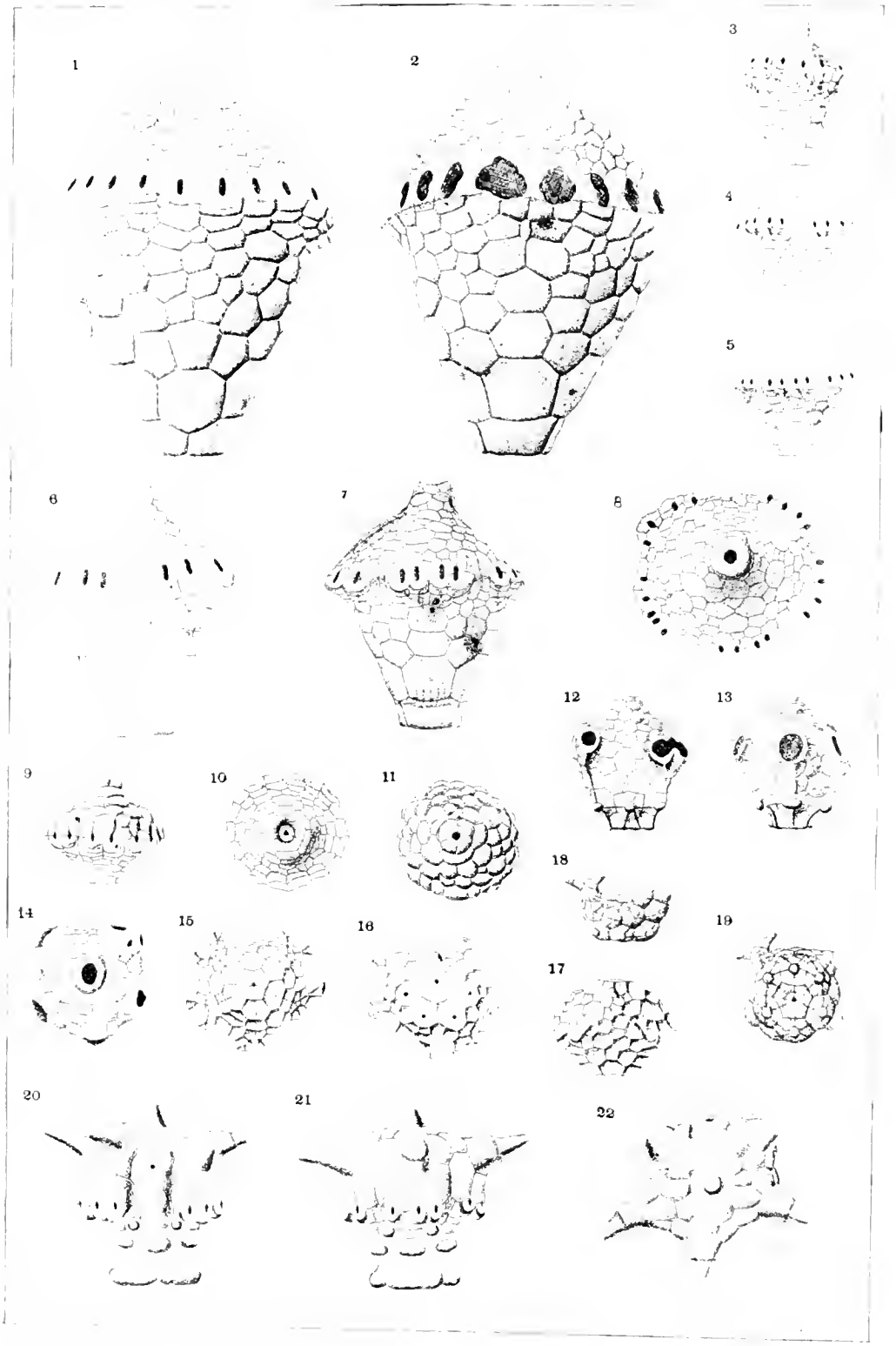
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PLATE IV.

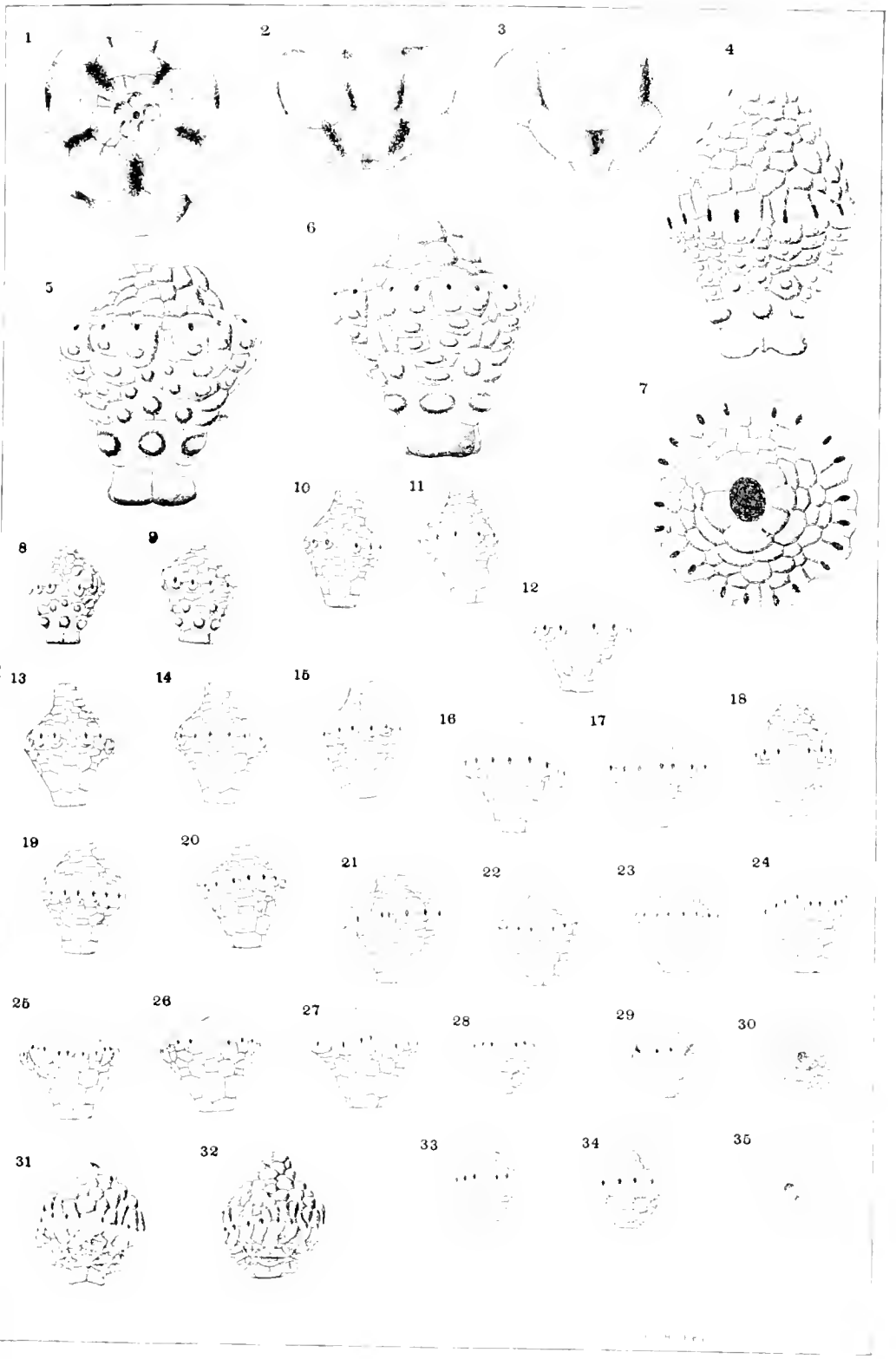
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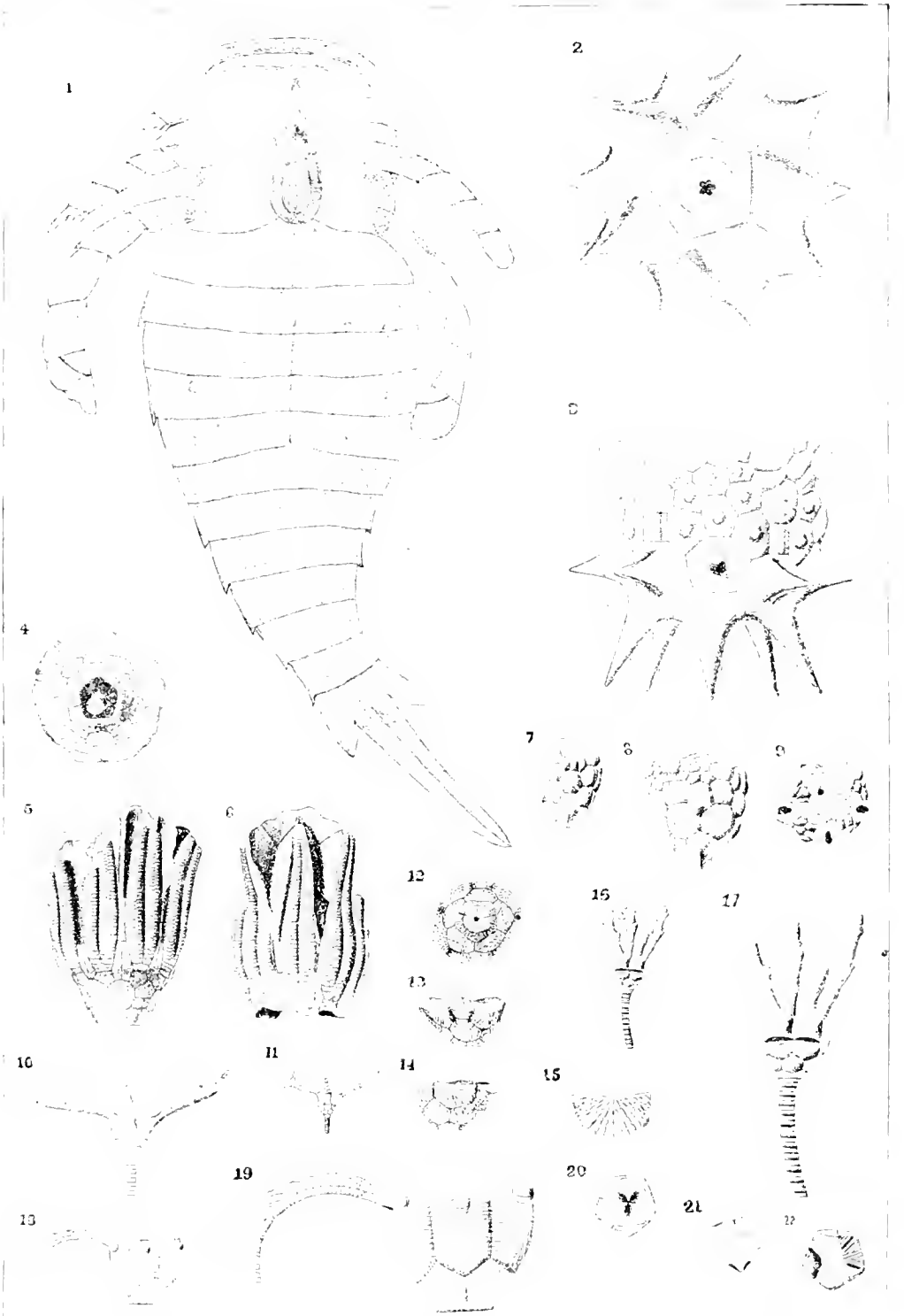
PLATE V.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